Hydrometeorology Testbed
HMT

Dr. Marty Ralph
NOAA/ESRL/Physical Sciences Division

Contributors:
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1 May 2012

NOAA Testbeds and Proving Grounds Workshop
ESRL, Boulder, Colorado

Outline

- HMT Overview, Team and Structure
- Selected accomplishments
- Major Activity Area Plans
- Emerging directions

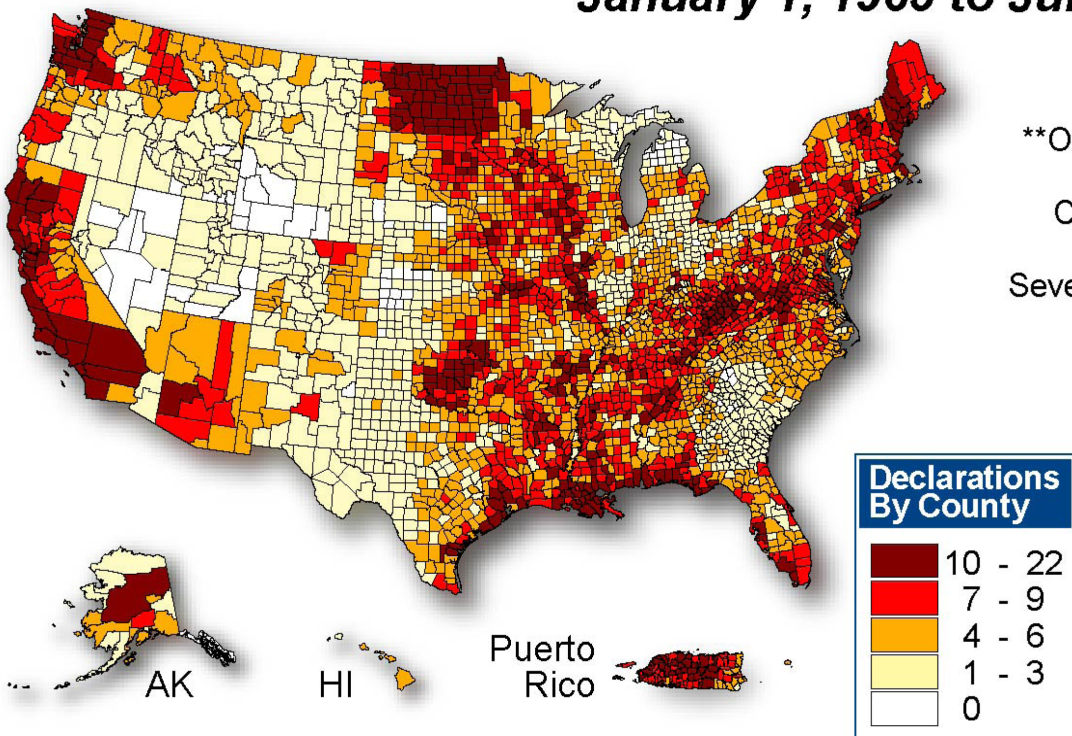
NOAA Hydrometeorology Testbed (HMT)

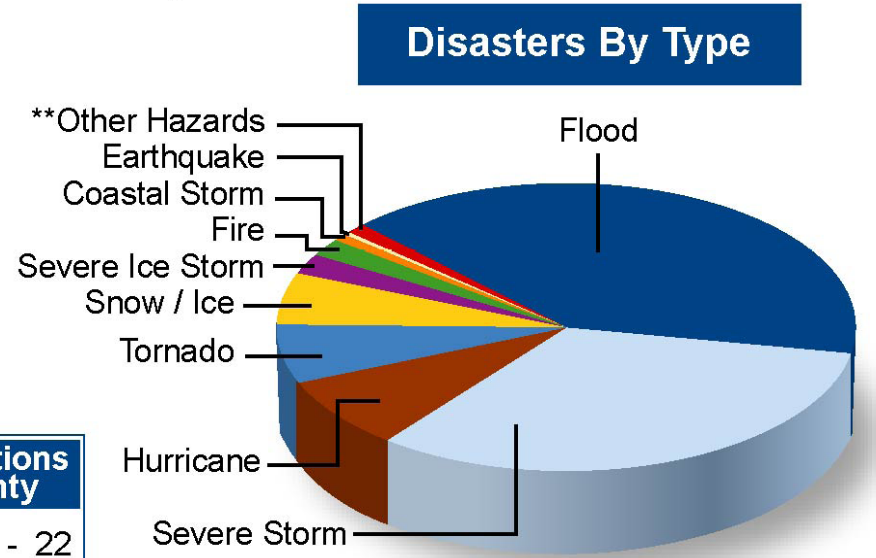
The Hydrometerology Testbed (HMT) conducts research on precipitation and weather conditions that can lead to flooding, and fosters transition of scientific advances and new tools into forecasting operations. HMT's outputs support efforts to balance water resource demands and flood control in a changing climate. HMT aims to:

- accelerate the development and prototyping of advanced hydrometeorological observations, models, and physical process understanding
- fosters infusion of these advances into operations of the National Weather Service (NWS) and the National Water Center (NWC)
- supports the broader needs for 21st Century precipitation information for flood control, water management, and other applications

Presidential Disaster Declarations

January 1, 1965 to June 1, 2003





**Other Hazards include: Drought, Volcano, Other, Freezing, Mud/Landslide, Typhoon, Human Cause, Terrorist, Dam/Levee Break, Toxic Substances

Mapped Total: 1,214*

* Prior to January 1, 1965, 185 declarations did not have county designations. Therefore, of the total declared disasters (1,399), only 1,214 are included in the Mapped Total.

Source: *FEMA's National Emergency Management Information System*

- Floods annually cause 80 fatalities + $5.2 B damage on average (~50% of the annual average U.S. natural disaster losses)
- 2011 had 11 natural disasters in the U.S. exceeding $1 B in losses – most were related to flooding

Source: NOAA Economic Statistics, 2006

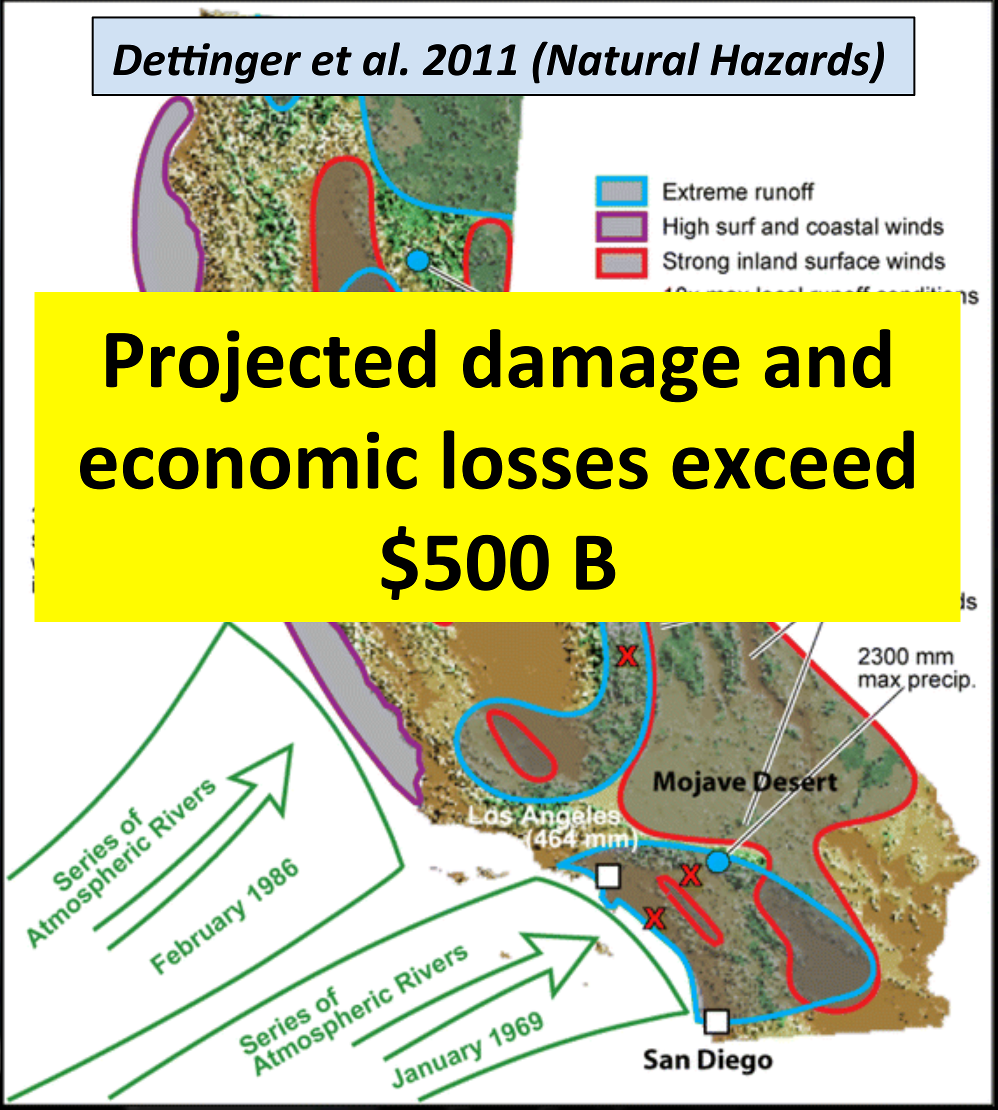
ARkStorm: An emergency preparedness scenario for California

USGS organized a large team of experts.

A meteorology team led by Mike Dettinger and Marty Ralph was formed and built a plausible physical scenario. Back-to-back extreme AR events (mostly based on actual 1969 and 1986 storms) struck over about 3 weeks . Considers the 1861/82 floods as an example.

The meteorological scenario was then given to follow-on groups of experts in damage assessment and economic disruption estimation and has become the basis for emergency preparedness exercises.

Dettinger et al. 2011 (Natural Hazards)



Projected damage and economic losses exceed $500 B

ARkStorm

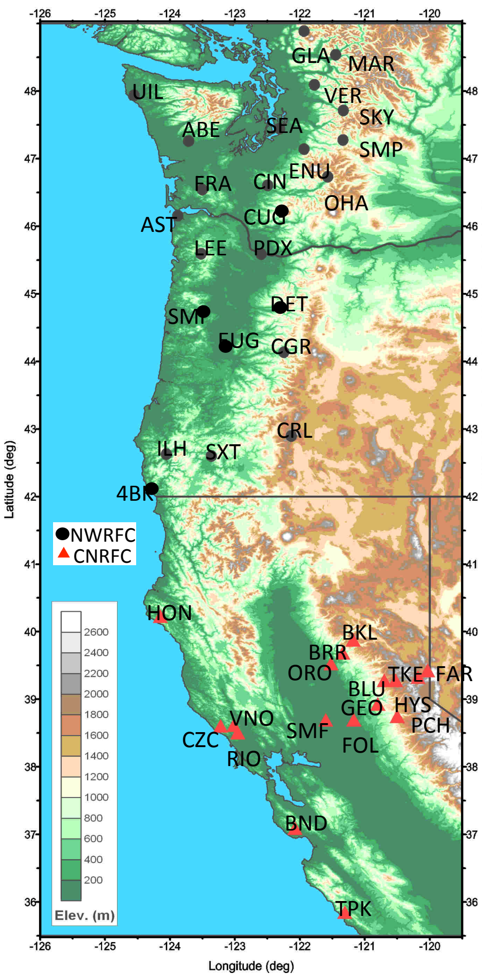
USGS
science for a changing world

Assessment of Extreme Quantitative Precipitation Forecasts (QPFs) and Development of Regional Extreme Event Thresholds Using Data from HMT-2006 and COOP Observers

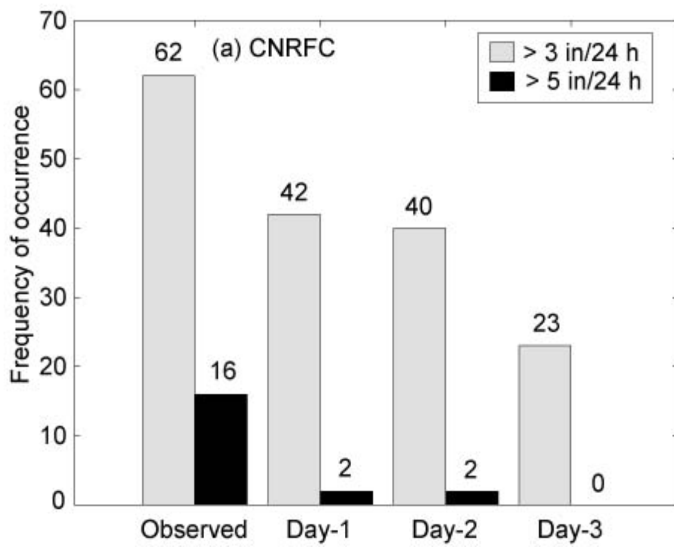
F. M. Ralph, E. Sukovich, D. Reynolds, M. Dettinger, S. Weagle, W. Clark, and P. J. Neiman

Journal of Hydrometeorology (2010)

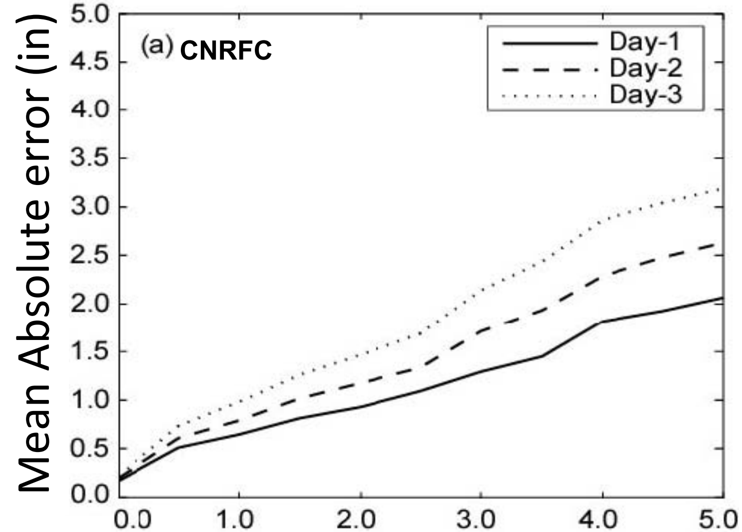
The Forecasting Challenge



41 West Coast sites were used



Forecasting large precipitation amounts is difficult



On average forecasts are 50% less than observations

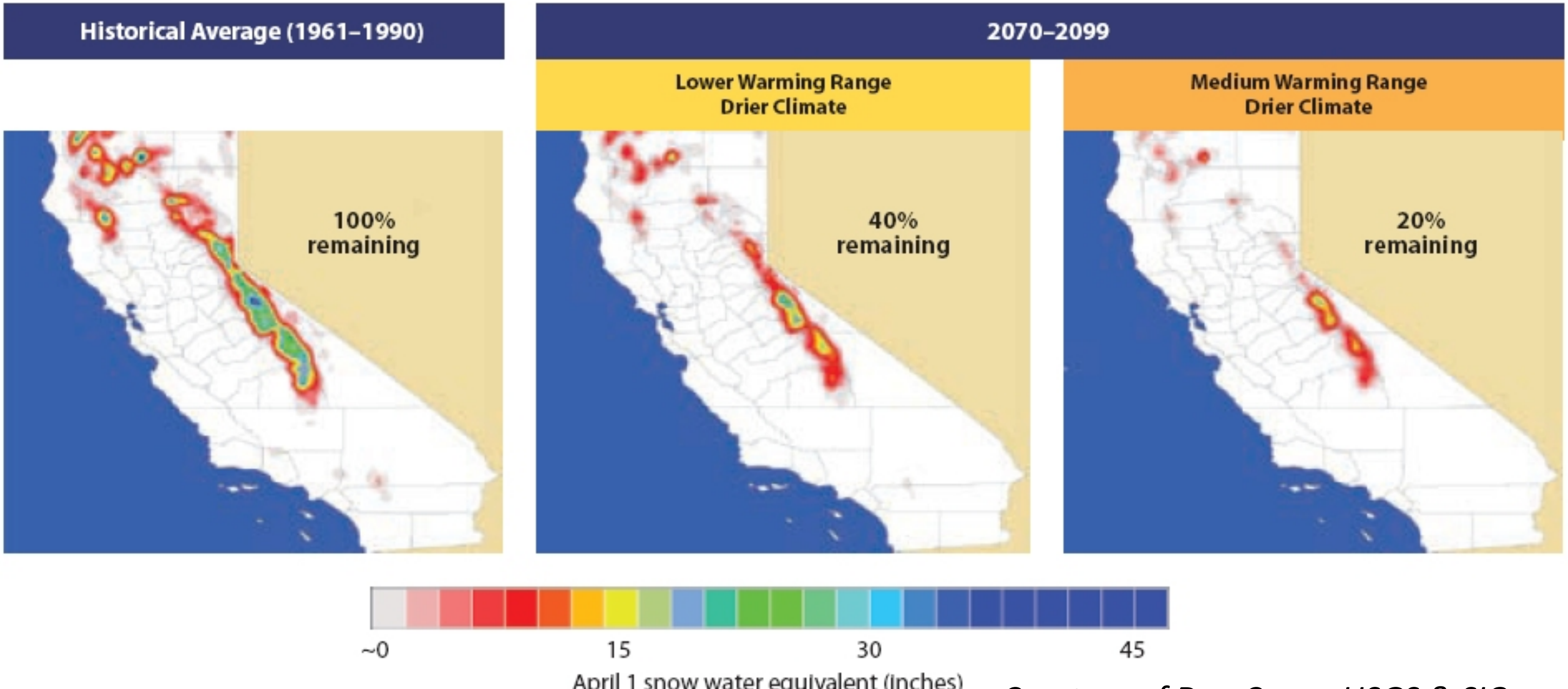
Of the 20 dates with >3 inches of precipitation in 1 day, 18 were associated with ARs.

“Water is the next oil.”

- **Conclusion of a National Security report on risks associated with changing climate.**

Decreasing California Snowpack

Snow pack acts as a natural reservoir for summer and fall water supply.
Its capacity is projected to decrease significantly in a warmer climate.



Courtesy of Dan Cayan USGS & SIO

Under an ensemble of climate scenarios, there is marked reduction in spring snow pack:

- by 2100 the chance of achieving historical median SWE falls to about 10%.
- by 2100 the chance of SWE at or below 10 percentile historical rises to about 40%.

NAS and NOAA Drivers

When Weather Matters (Nat'l Academies Press)

- Need for enhanced mesoscale profiling networks to improve forecasts of very high impact events
- Need for improved hydrologic forecast skill and new hydrometeorological observations for model initialization, improvement of model physics, data assimilation , validation

Observing Weather and Climate from the Ground Up (Nat'l Academies Press)

- Importance of observational testbeds as a research to operations tool

NOAA Next Generation Strategic Plan

- *Weather-Ready Nation Goal*
    - Reduced loss of life, property, and disruption from high-impact events
    - Improved freshwater resource management
- *Climate Adaptation and Mitigation Go*al
    - Improved scientific understanding of the changing climate system and its impacts

Key Partners and Stakeholders - NOAA

OAR

- ESRL Physical Sciences Division
- ESRL Global Systems Division
- National Integrated Drought and Information Systems
- National Severe Storms Laboratory

NESDIS

- Center for Satellite Applications and Research

NWS

- Various Local Weather Forecast Offices
- Various Regional River Forecast Centers
- Various Regional Headquarters Offices
- National Operational Hydrologic Remote Sensing Center
- NCEP Environmental Modeling Center
- Office of Hydrologic Development
- NCEP Environmental Modeling Center
- National Operational Hydrologic Remote Sensing Center
- Hydrometeorolgical Prediction Center
- Western Regional Climate Center
- Collaborative Science Technology and Applied Research Program

Key Partners and Stakeholders – Non-NOAA

Federal

U.S. Army Corps of Engineers
U.S. Geological Survey

State

California Department of Water Resources
Renaissance Computing Institute

Local

Sacramento Regional Flood Control Agency
Sonoma County Water Agency

Academic

UCAR Developmental Testbed Center
Colorado State University
University of Colorado
University of Washington
Scripps Institution for Oceanography

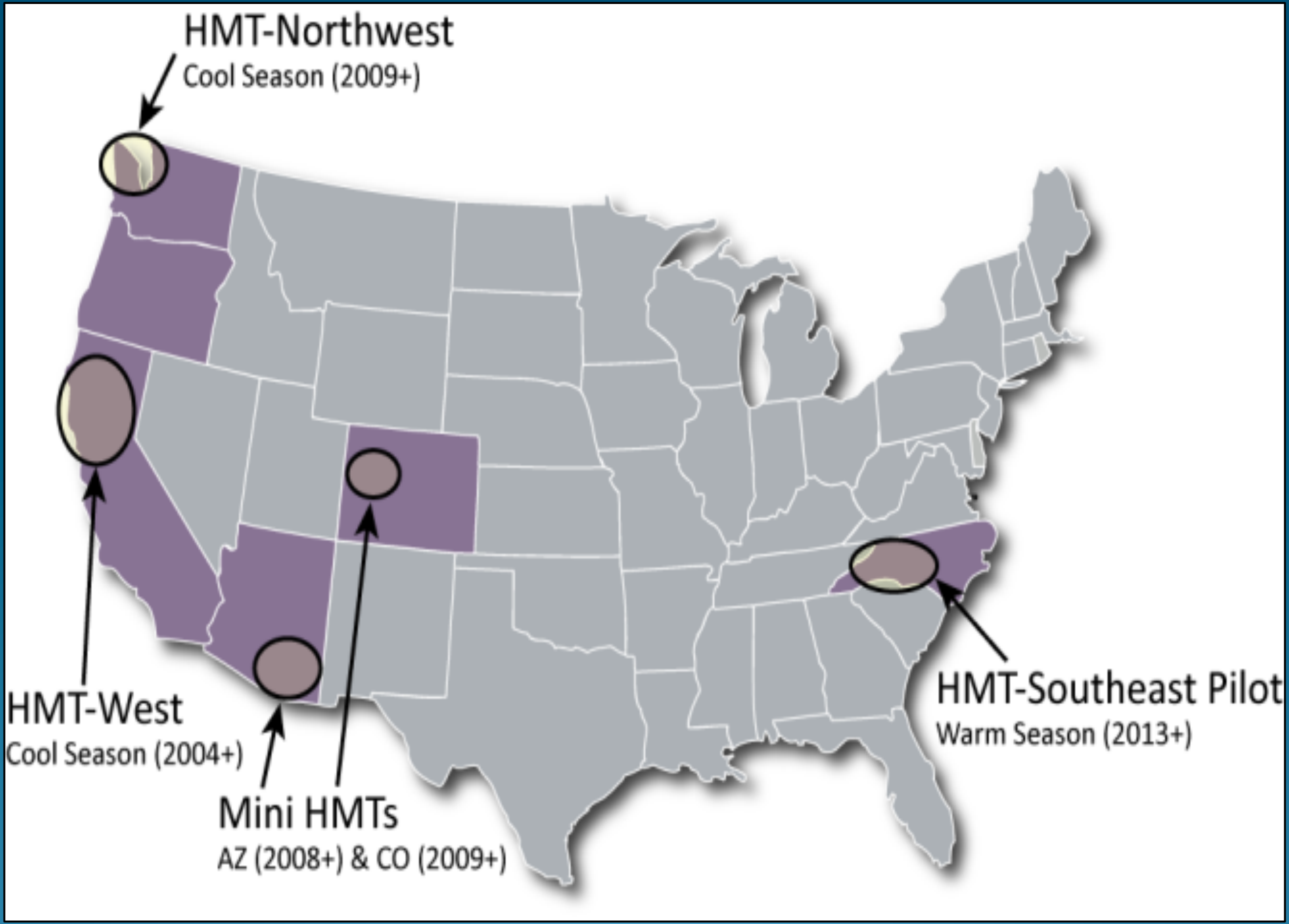
Related

California Energy Commission

HMT-West Meeting 2010

Santa Rosa, CA

HMT Locations



HMT Organization

Program Director
Marty Ralph

Program Coordinator
Richard Lataitis

Science Coordinators
Allen White / Rob Cifelli

Field Coordinator
Clark King

Transition Coordinators
David Reynolds / Tim Schneider

Major Activity Areas

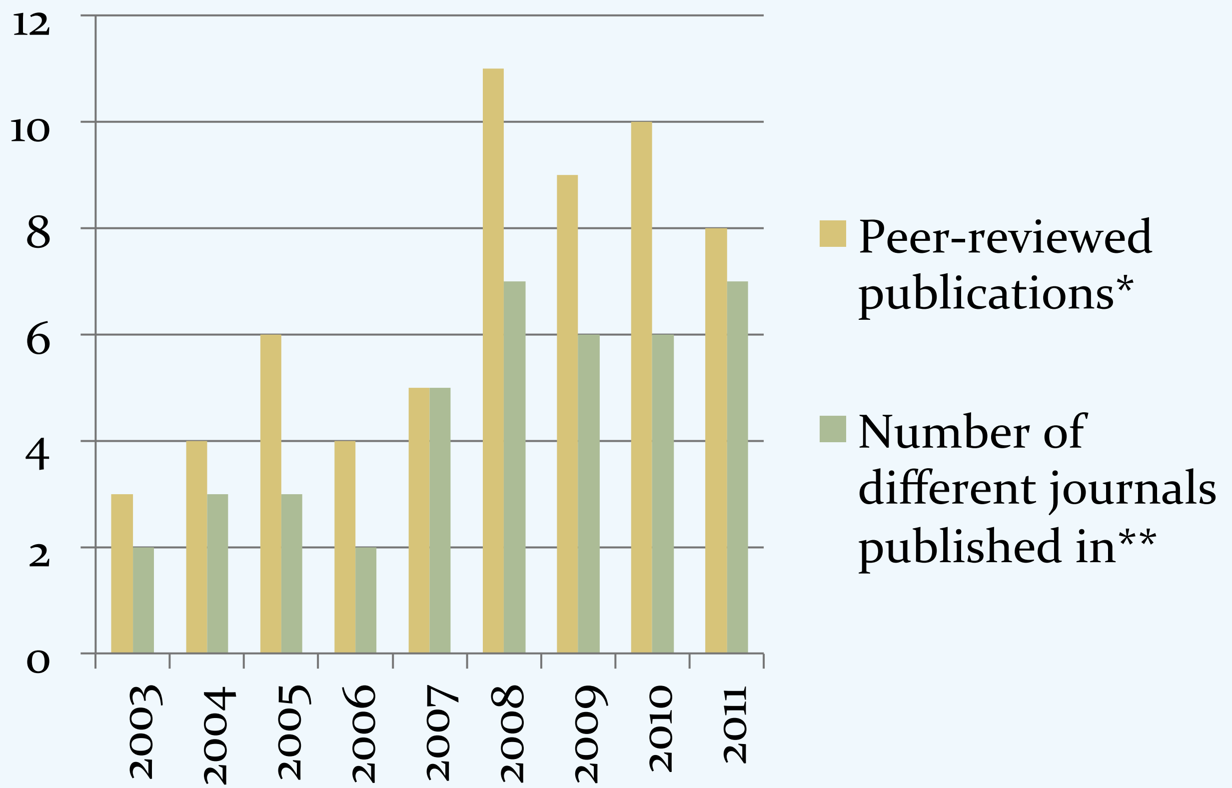
Stakeholder Groups

	Quantitative Precipitation Estimation	Quantitative Precipitation Forecasting	Snow Information	Hydrologic and Surface Processes	Decision Support Tools
HMT West/Northwest Allen White	Rob Cifelli Ken Howard	Ellen Sukovich Zoltan Toth	Allen White Art Henkel	Lynn Johnson Ed Clark	TBD
HMT Southeast Pilot Rob Cifelli	Rob Cifelli Ken Howard				
Transitions David Reynolds/Tim Schneider	OAR NWS	OAR NWS	OAR NWS	OAR NWS	OAR NWS

hmt.noaa.gov

“HMT News” Stories added every 1-2 weeks

HMT Uses Scientific Peer Review to Ensure Results Have A Solid Scientific Foundation and Multidisciplinary Impacts

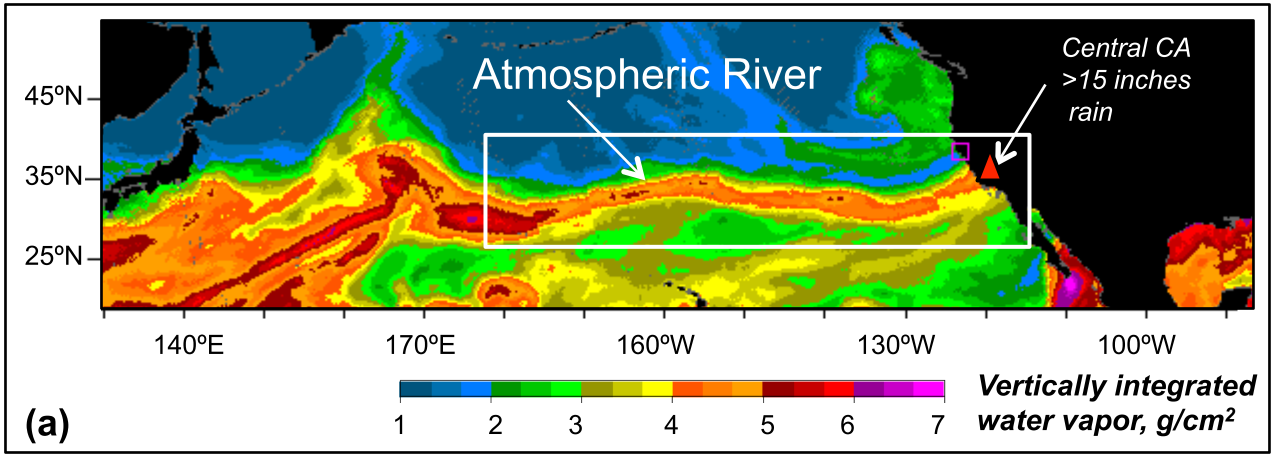


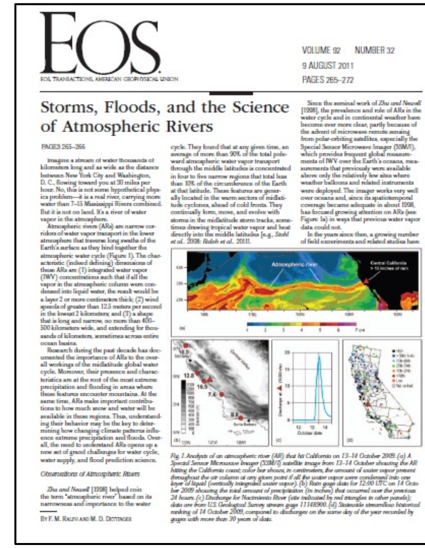
*Papers must have used data or model information directly from HMT or its predecessors CALJET and PACJET (full bibliography with these 60 publications is available at hmt.noaa.gov)

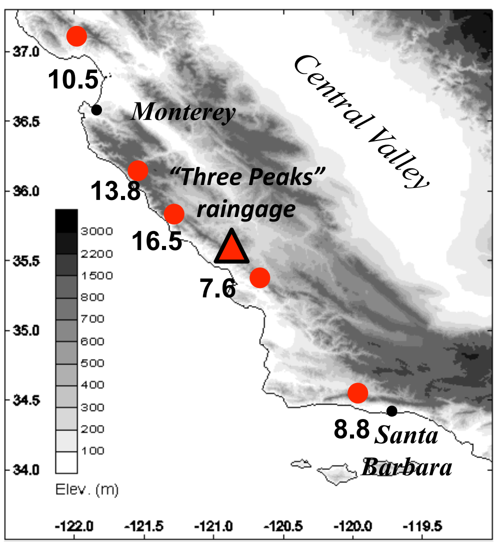
**Journals published in (15): Geophys. Res. Lett., J. Hydrometeor., Mon. Wea. Rev., J. Tech., Water Resources Research, Water Management, J. Climate, Bull. Amer. Meteor. Soc, Weather and Forecast, IEEE Trans. Geoscience and Remote Sensing, etc…

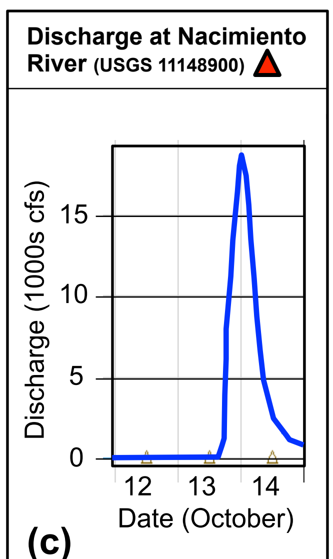
Selected Accomplishments

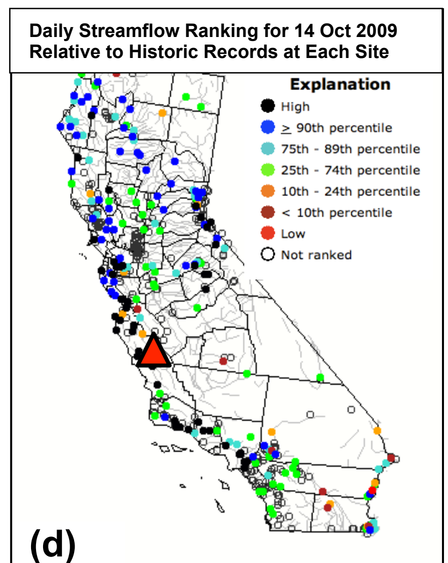
Research has Identified Atmospheric Rivers as the Primary Meteorological Cause of Extreme Precipitation & Flooding on U.S. West Coast





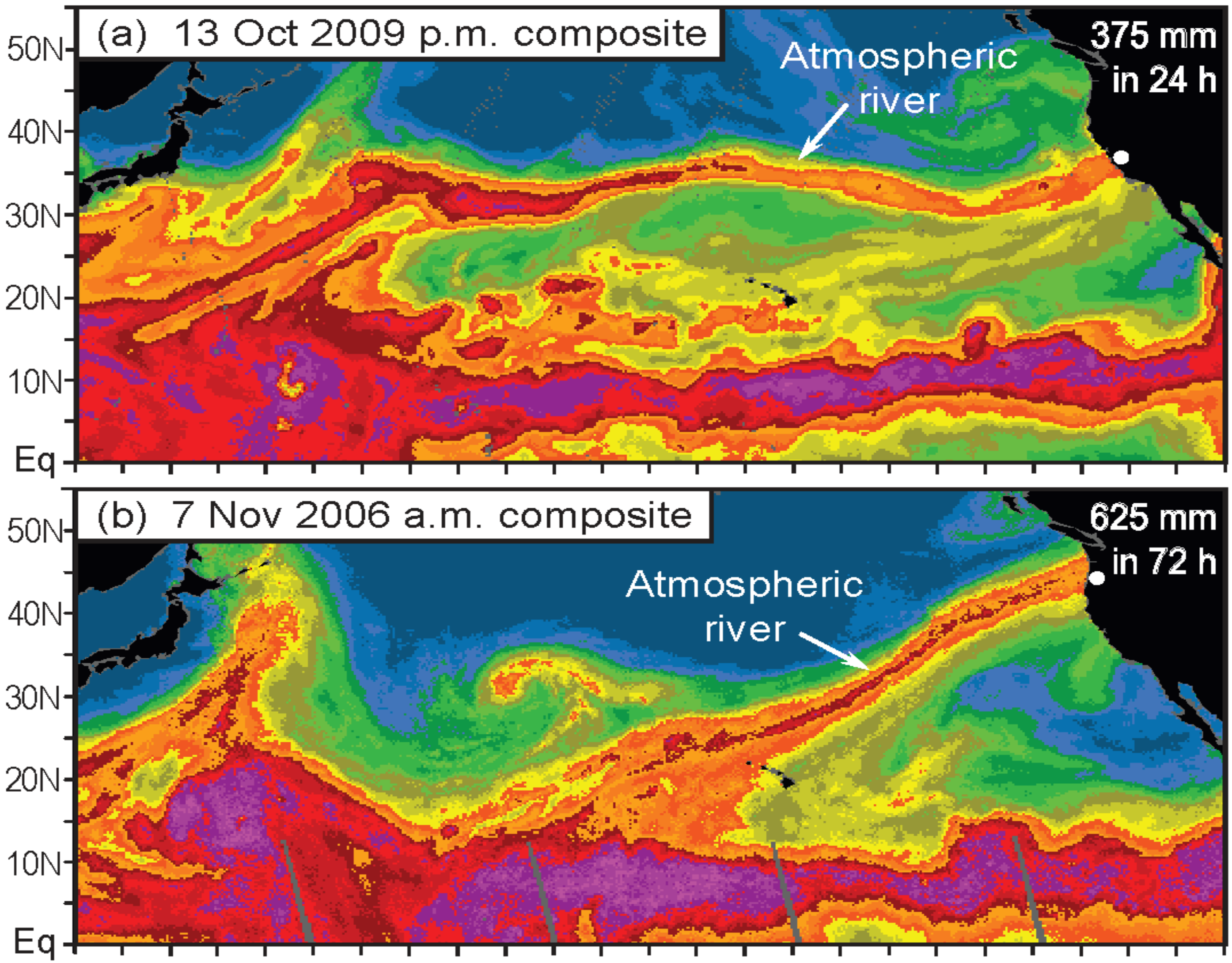






Ralph, F.M., and M.D. Dettinger, 2011: Storms, Floods and the Science of Atmospheric Rivers. *EOS, Transactions, Amer. Geophys. Union.*, **92**, 265-266.

Atmospheric rivers: SSM/I Satellite data for two recent examples that produced extreme rainfall and flooding



From Ralph et al. 2011, Mon. Wea. Rev.

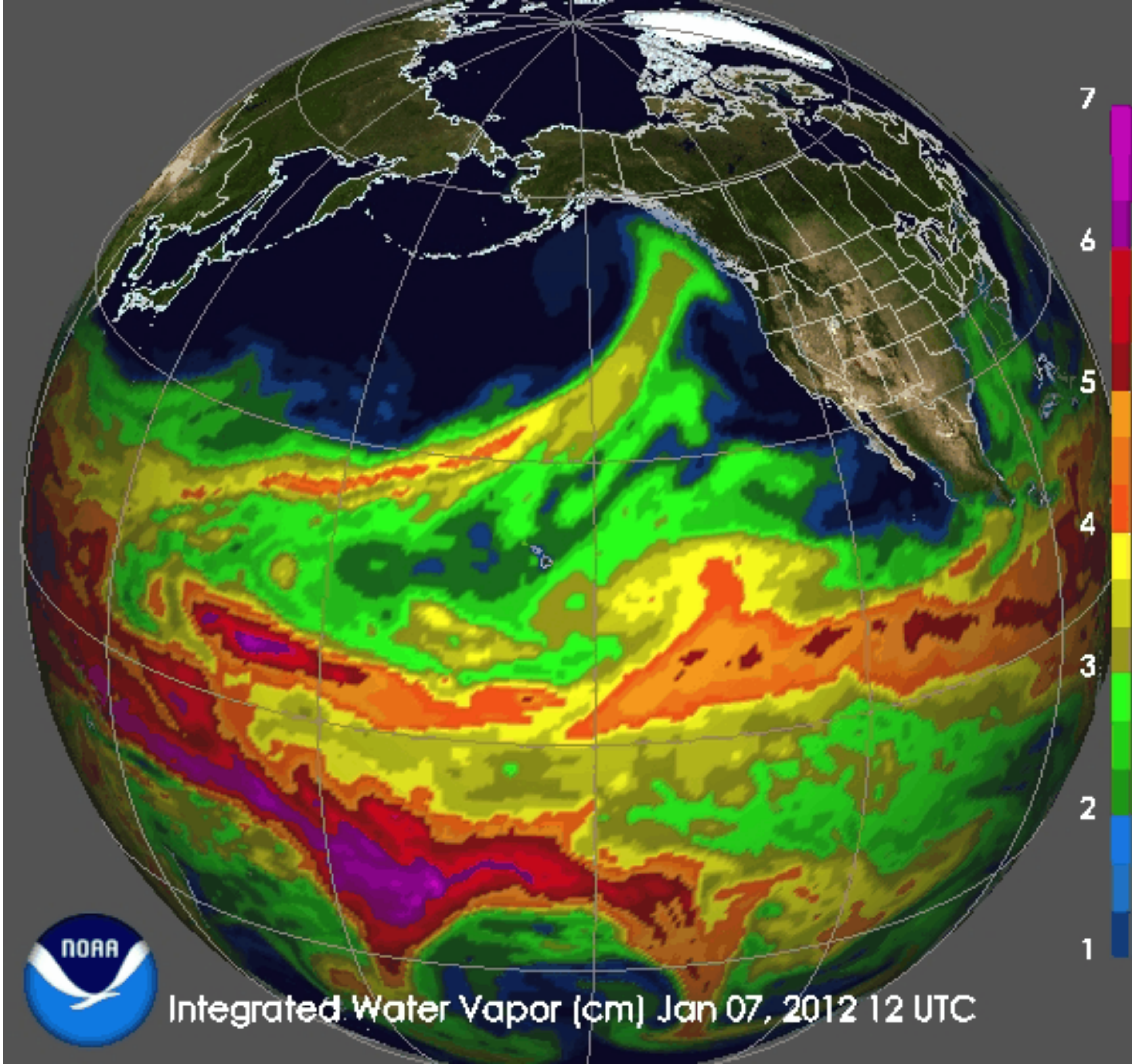
These color images represent satellite observations of atmospheric water vapor over the oceans.

Warm colors = moist air
Cool colors = dry air

ARs can be detected with these data due to their distinctive spatial pattern.

In the top panel, the AR hit central California and produced 18 inches of rain in 24 hours.

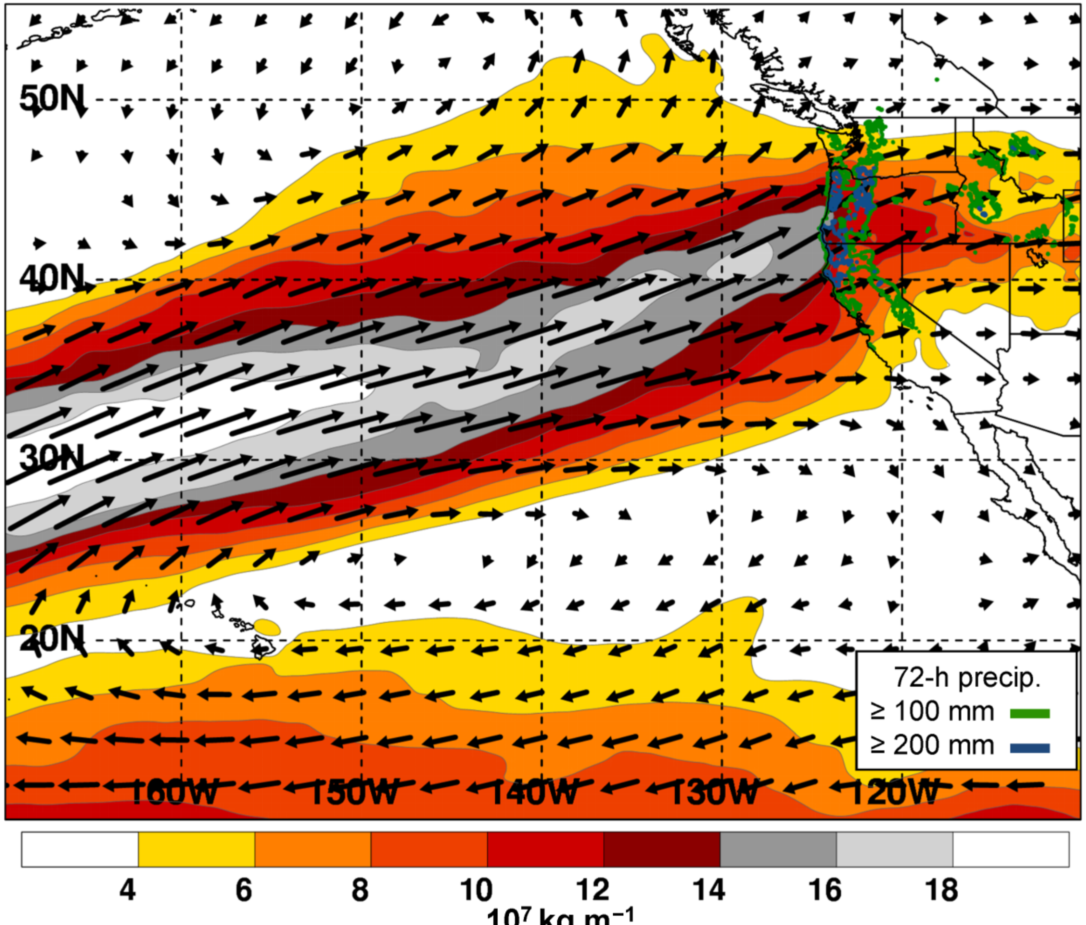
In the bottom panel, the AR hit the Pacific Northwest and stalled, creating over 25 inches of rain in 3 days.

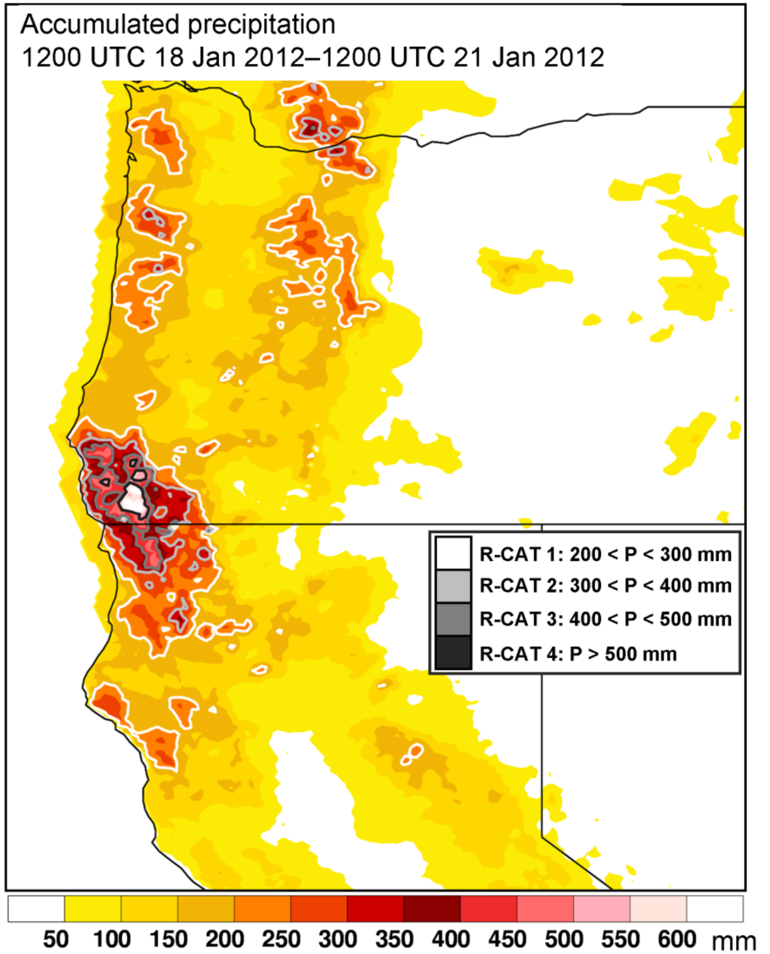

7
6
5
4
3
2
1
NOAA
Integrated Water Vapor (cm) Jan 07, 2012 12 UTC

18–21 Jan 2012 AR Event *(analysis courtesy of Ben Moore, Jay Cordeira)*

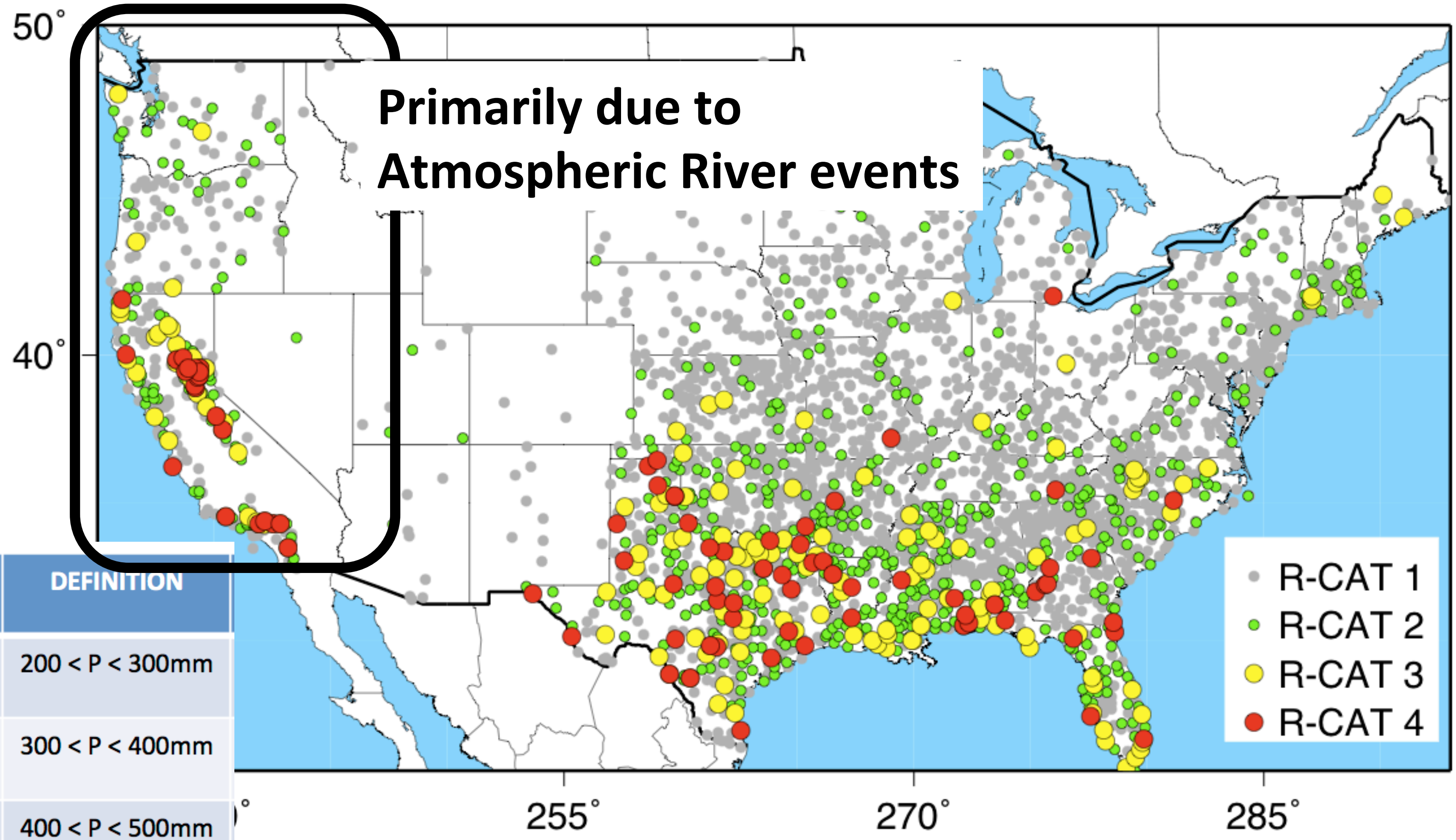
- The long duration of AR conditions in Oregon and northern California supported widespread heavy rainfall
- 72-h precipitation totals exceeding 100 mm were common along the west coast, with largest amounts observed in southwestern Oregon and northwestern CA
- Localized precip. totals ranged from 400 mm to >500 mm (R-CATs 3–4) in this region

Time-integrated IVT 12 UTC 18 Jan–12 UTC 21 Jan





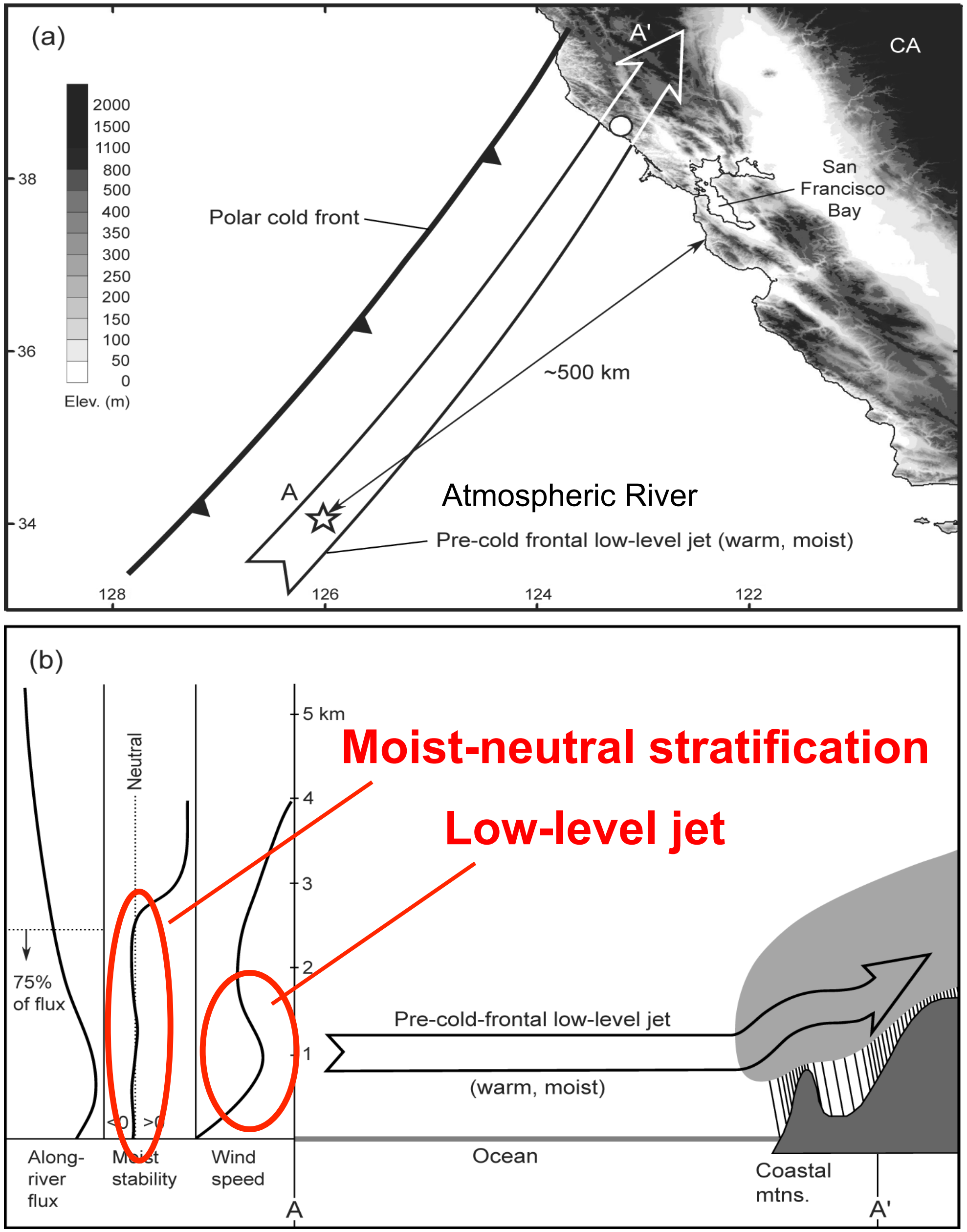
LARGEST 3-DAY PRECIPITATION TOTALS, 1950-2008



R-CAT	DEFINITION
1	200 < P < 300mm
2	300 < P < 400mm
3	400 < P < 500mm
4	P > 500mm

Ralph, F.M., and Dettinger, M.D., Historical and national perspectives on extreme west-coast precipitation associated with atmospheric rivers during December 2010: Bulletin of the American Meteorological Society, (in press, Nov 2011)

Vertical structure documented offshore



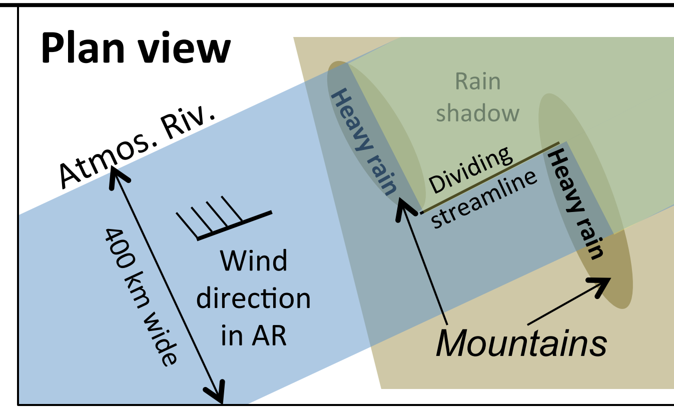
Dropsonde observations in low-level jets over the Northeastern Pacific Ocean from CALJET-1998 and PACJET-2001

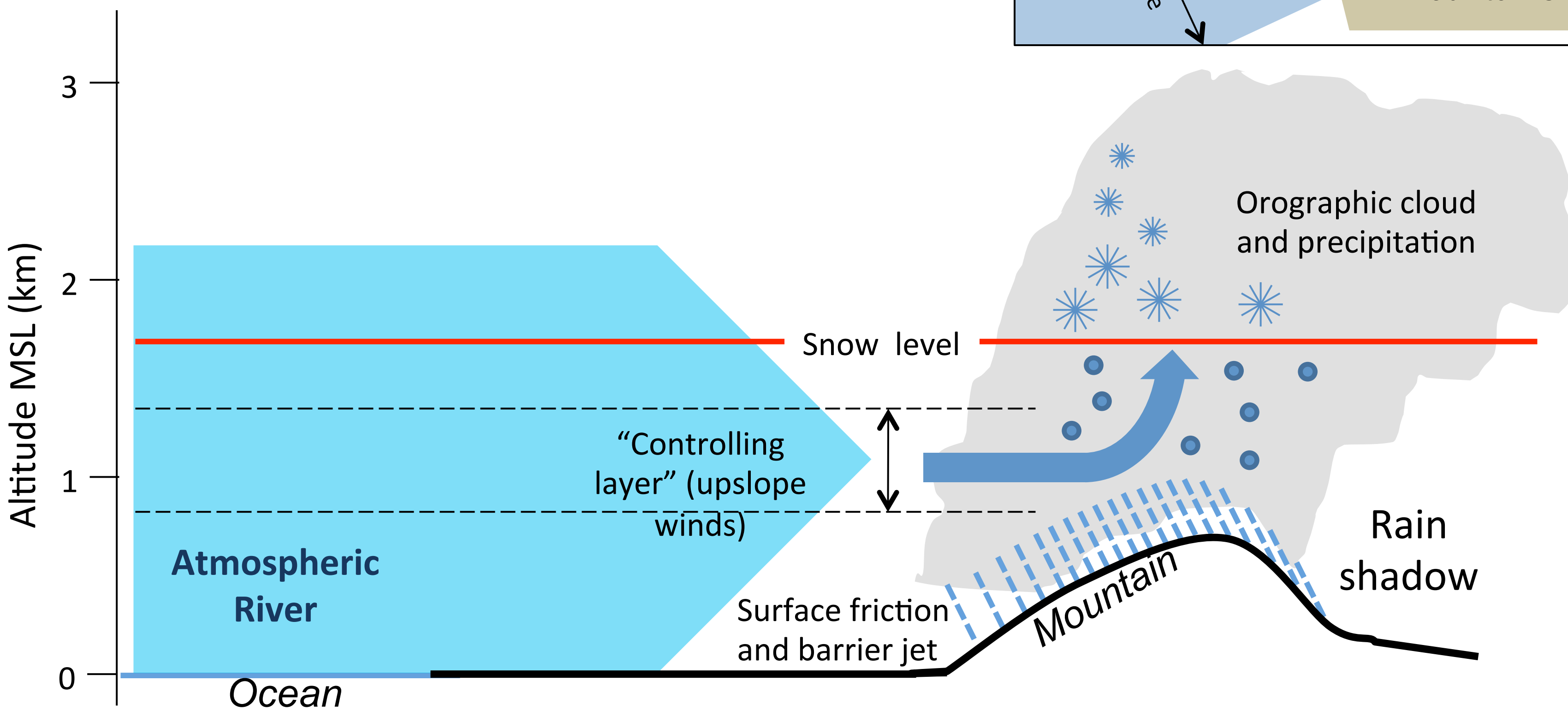
Ralph, F. M., P. J., Neiman and R. Rotunno

Mon. Wea. Rev., 2005

- 17 research aircraft missions offshore of CA documented atmospheric river structure.
- Wind, water vapor and static stability within atmospheric rivers are ideal for creation of heavy rainfall when they strike coastal mountains.
- These characteristics were present in both El Nino and Neutral winters

Key Features Associated with Atmospheric Rivers and Orographic Precipitation





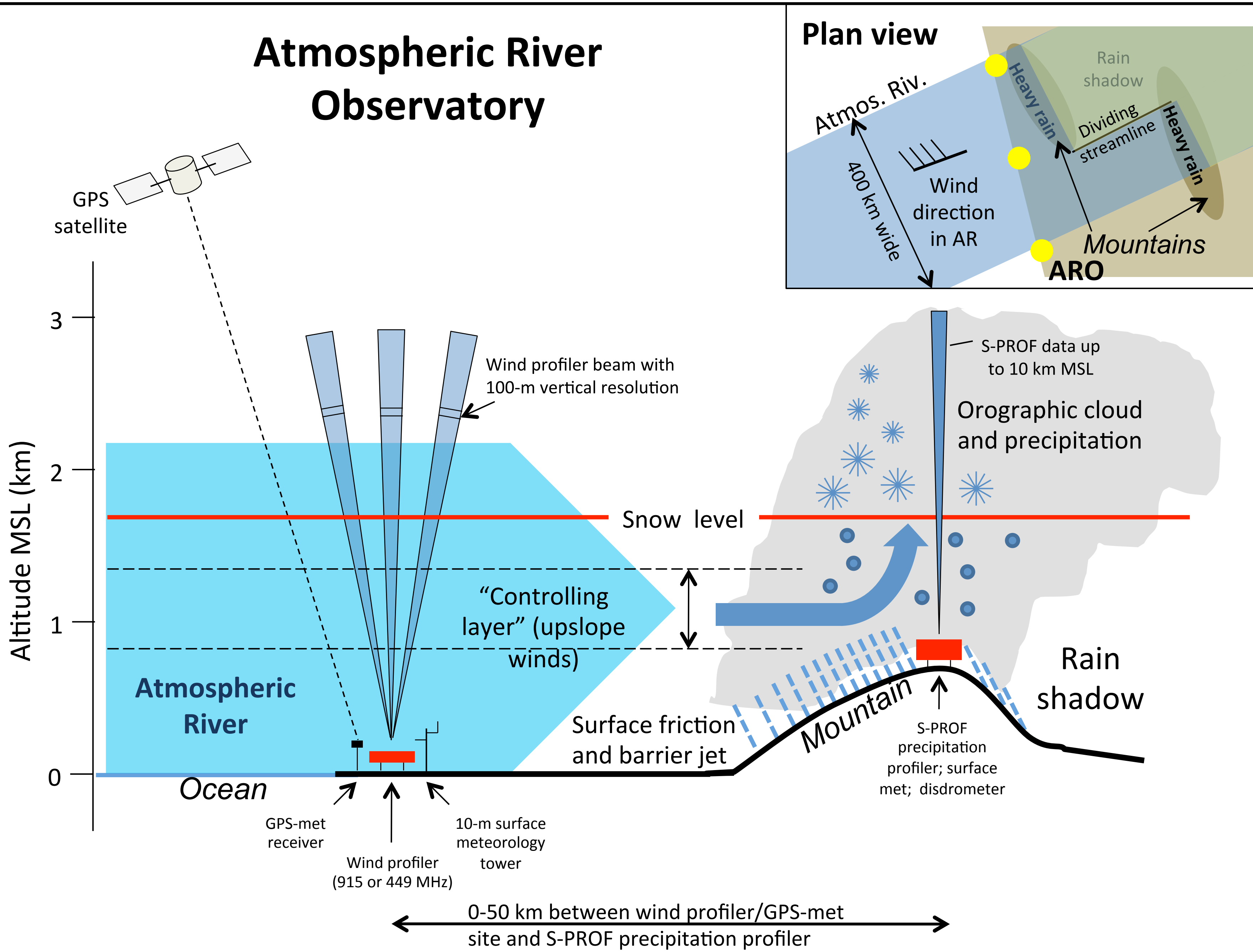
Physical conditions required for extreme precipitation

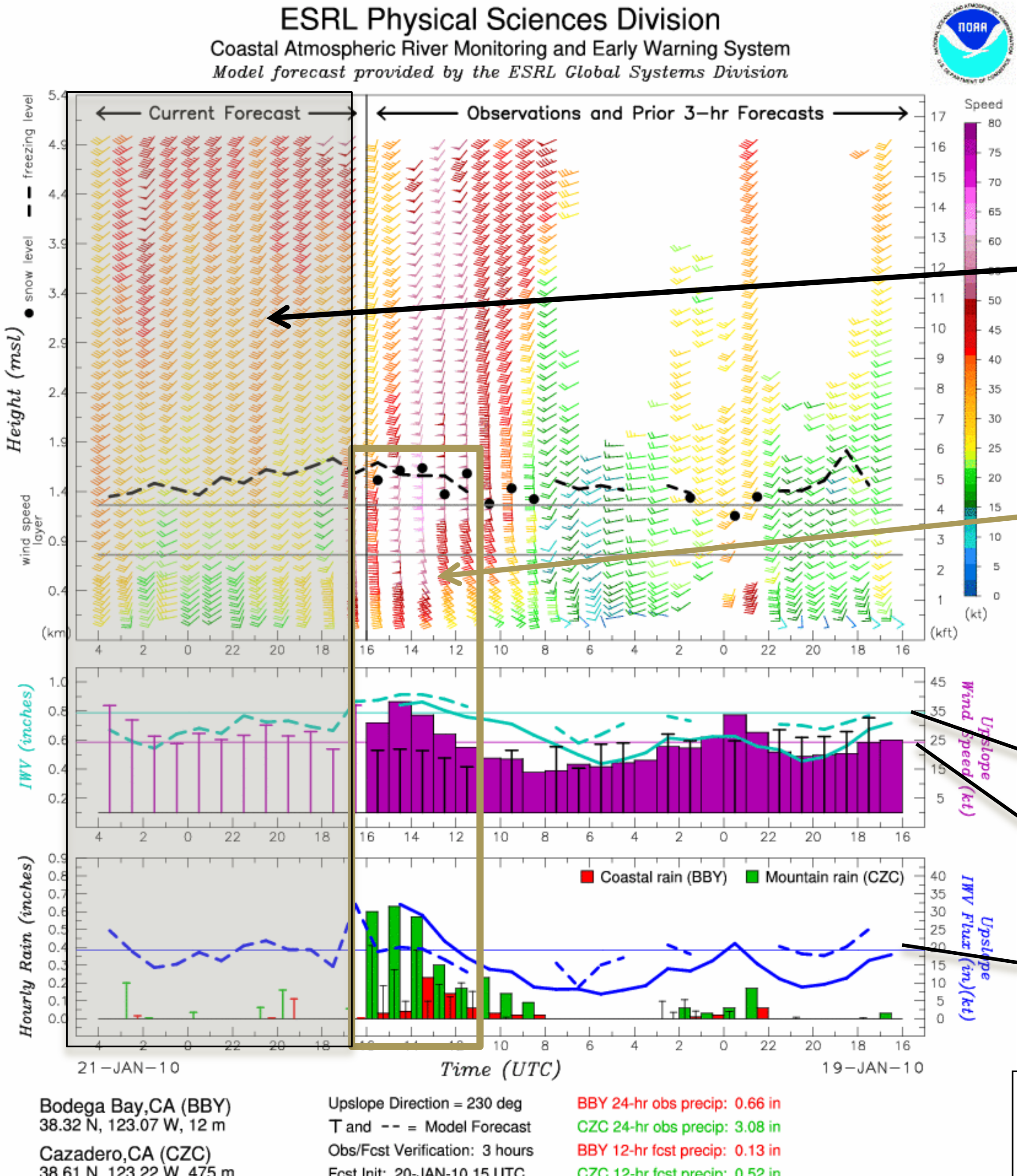
Wind in the controlling layer near 1 km MSL
speed > 12.5 m/s, and preferred direction

Water vapor content
vertically integrated water vapor (IWV) > 2 cm

Snow level
Above top of watershed

Atmospheric River Observatory





ARO Flux tool

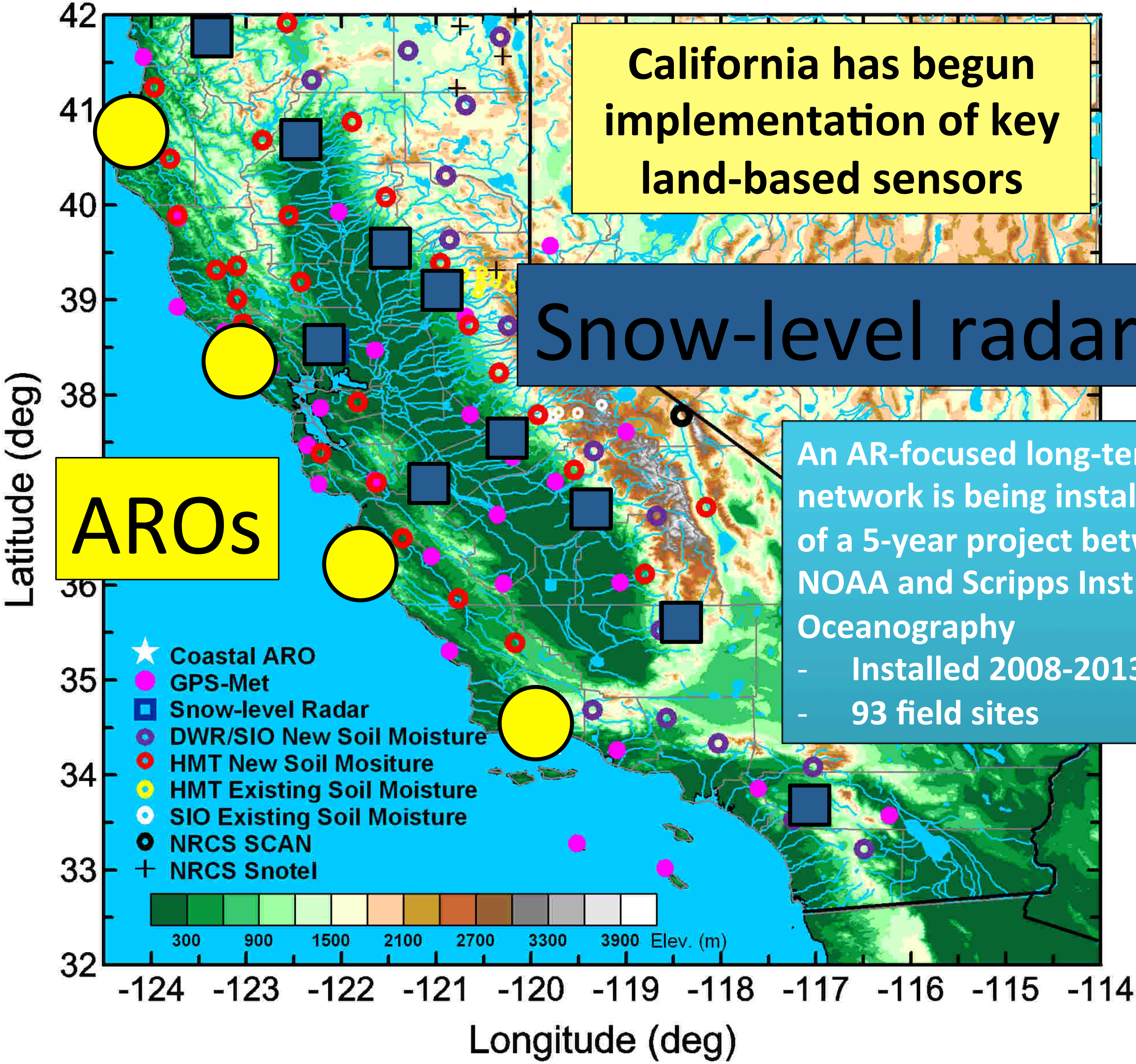
- available real time

AR conditions detected at Bodega Bay by ARO:
GPS-Met IWV > 2 cm,
Low-level jet >50 kt
Heavy rain >0.5 in/hr

Uses objective thresholds

Neiman et al., 2009
J. Water Management

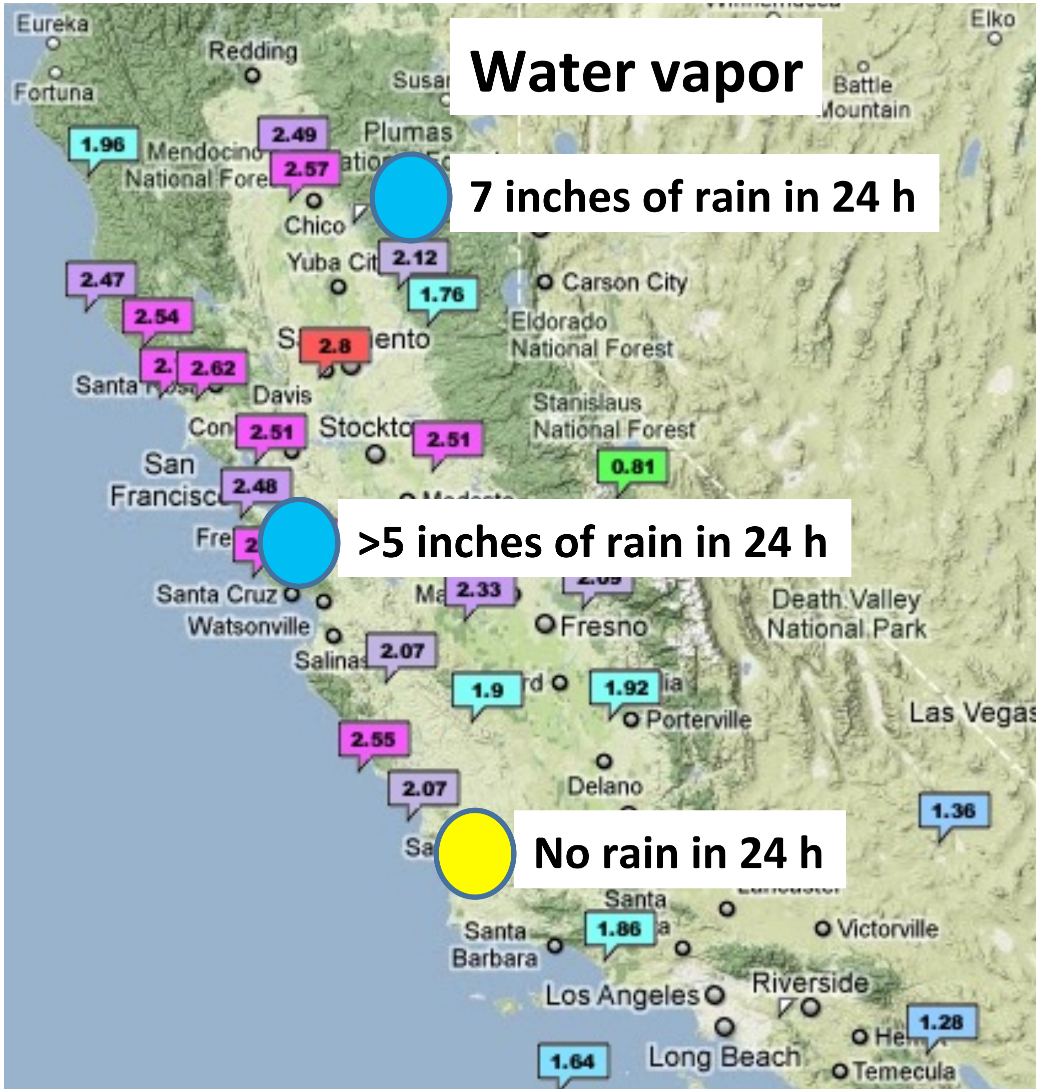
California has begun implementation of key land-based sensors



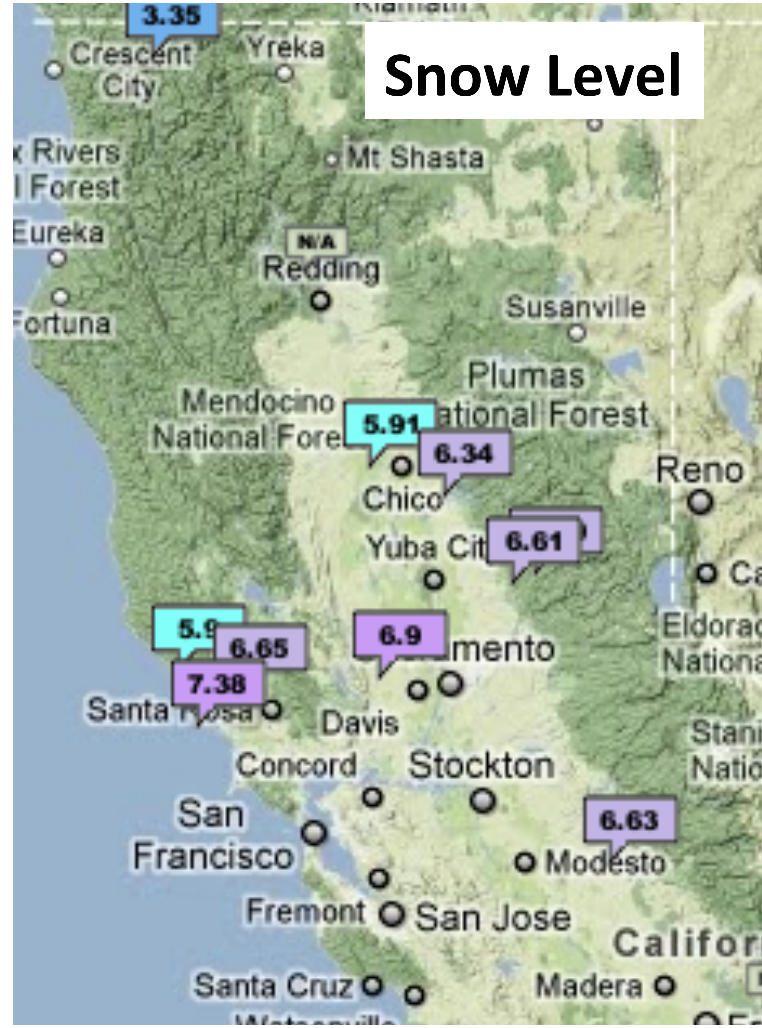
An AR-focused long-term observing network is being installed in CA as part of a 5-year project between CA-DWR, NOAA and Scripps Inst. of Oceanography

- Installed 2008-2013
- 93 field sites

New observations on 13 March 2012

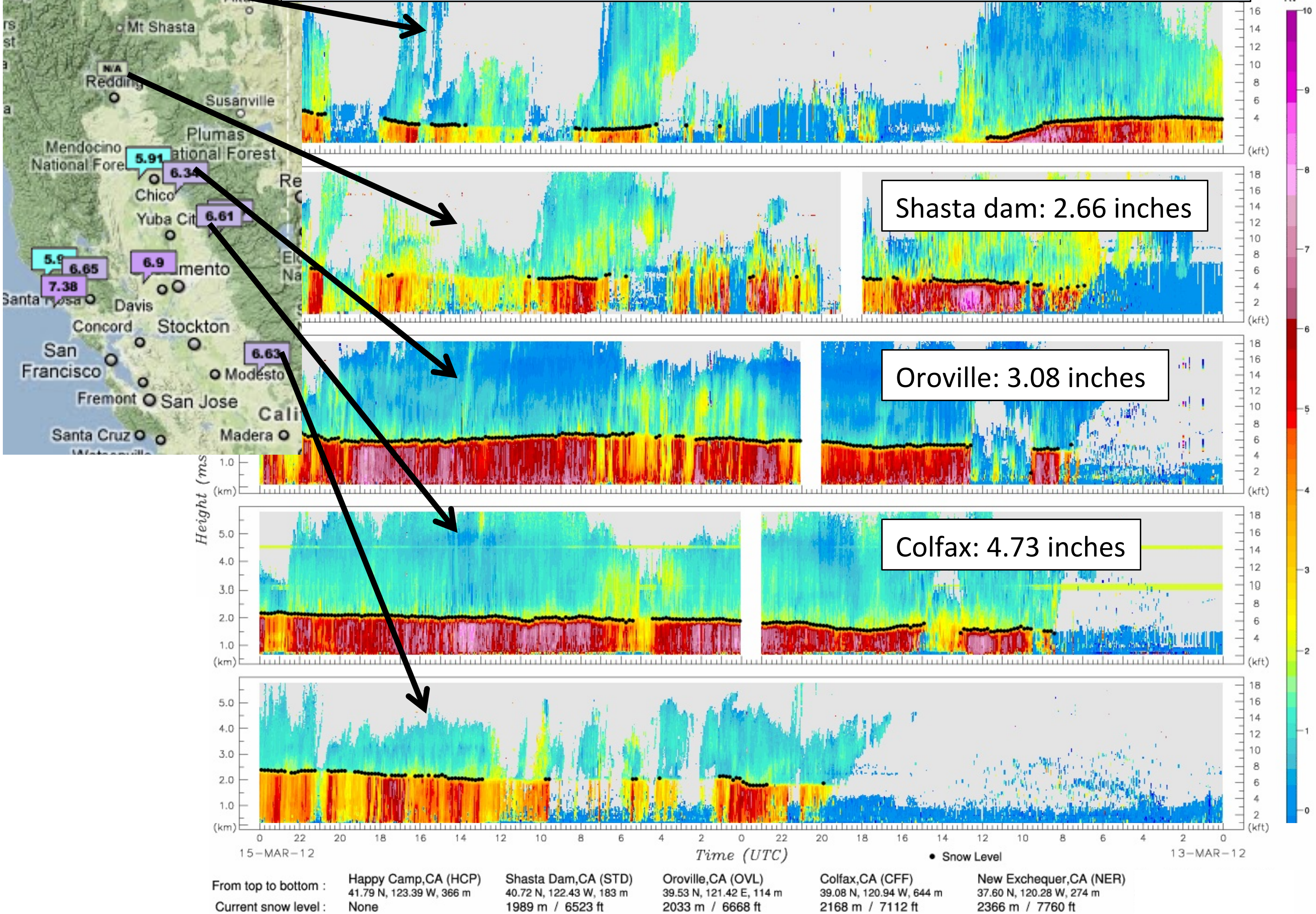


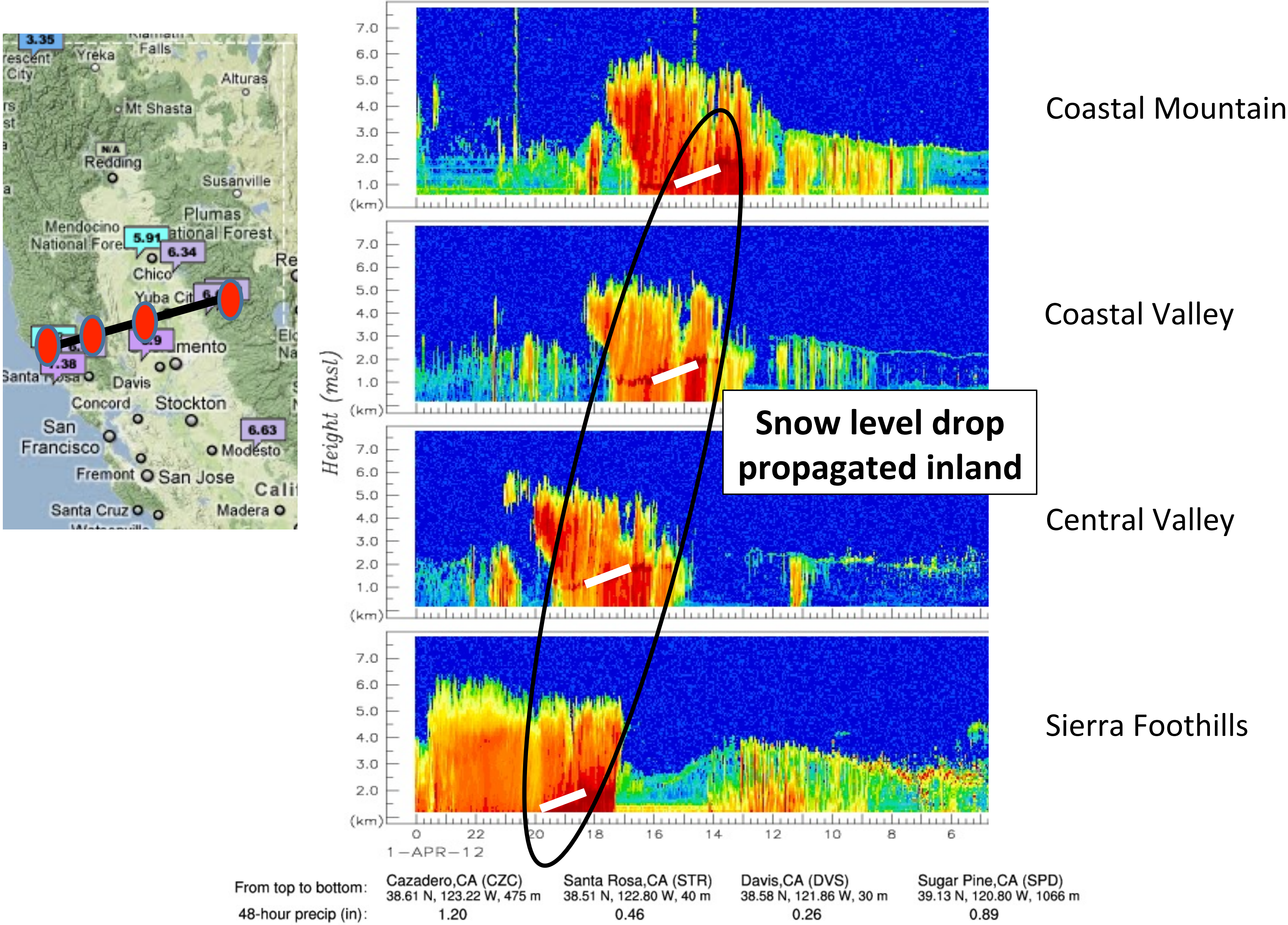
Vertically integrated water vapor (cm)



Snow level observing network showing the "snow level" in 1000's of feet above sea level. The snow level is the altitude above which precipitation is occurring as snow at that place and time.

FMCW radar network snow-level example

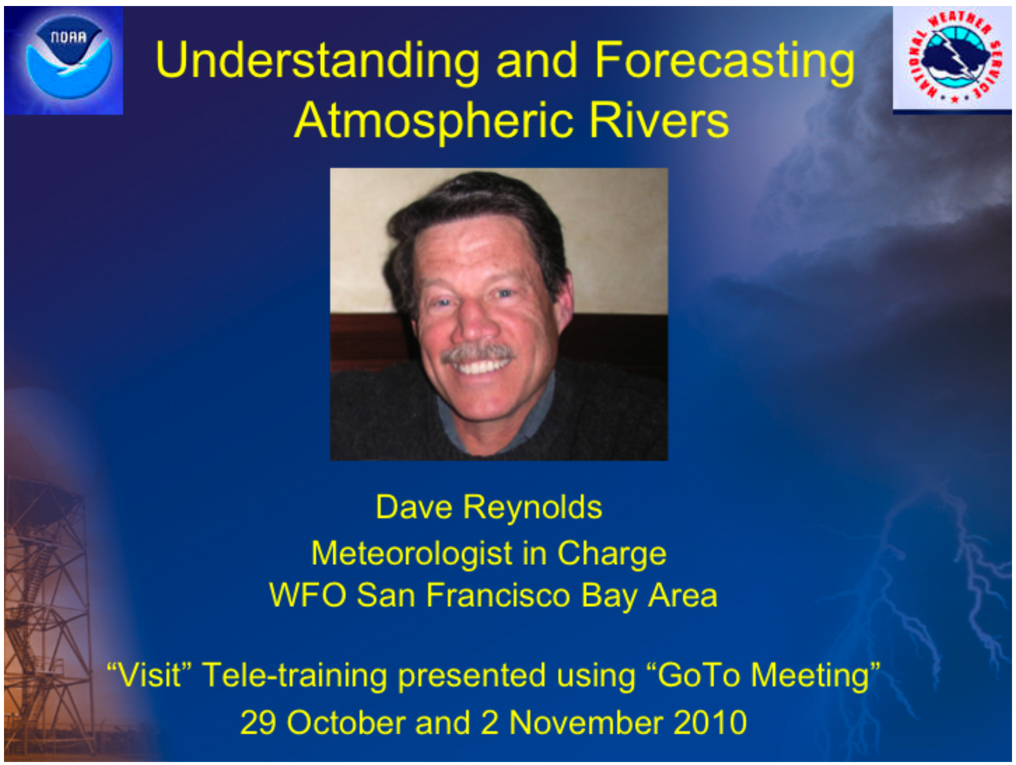




Yreka
Falls
Alturas
Mt Shasta
Redding
Susanville
Plumas
National Forest
Mendocino
National Fore
Chico
3.35
5.91
6.34
6.63
Santa Rosa
Davis
Concord
Stockton
San Francisco
Modesto
Fremont
San Jose
Santa Cruz
Madera
Coastal Mountain
Coastal Valley
Central Valley
Sierra Foothills
Snow level drop propagated inland
Height (msl)
(km)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
22
20
18
16
14
12
10
8
6
1-APR-12
From top to bottom:
Cazadero,CA (CZC)
38.61 N, 123.22 W, 475 m
Santa Rosa,CA (STR)
38.51 N, 122.80 W, 40 m
Davis,CA (DVS)
38.58 N, 121.86 W, 30 m
Sugar Pine,CA (SPD)
39.13 N, 120.80 W, 1066 m
48-hour precip (in):
1.20
0.46
0.26
0.89

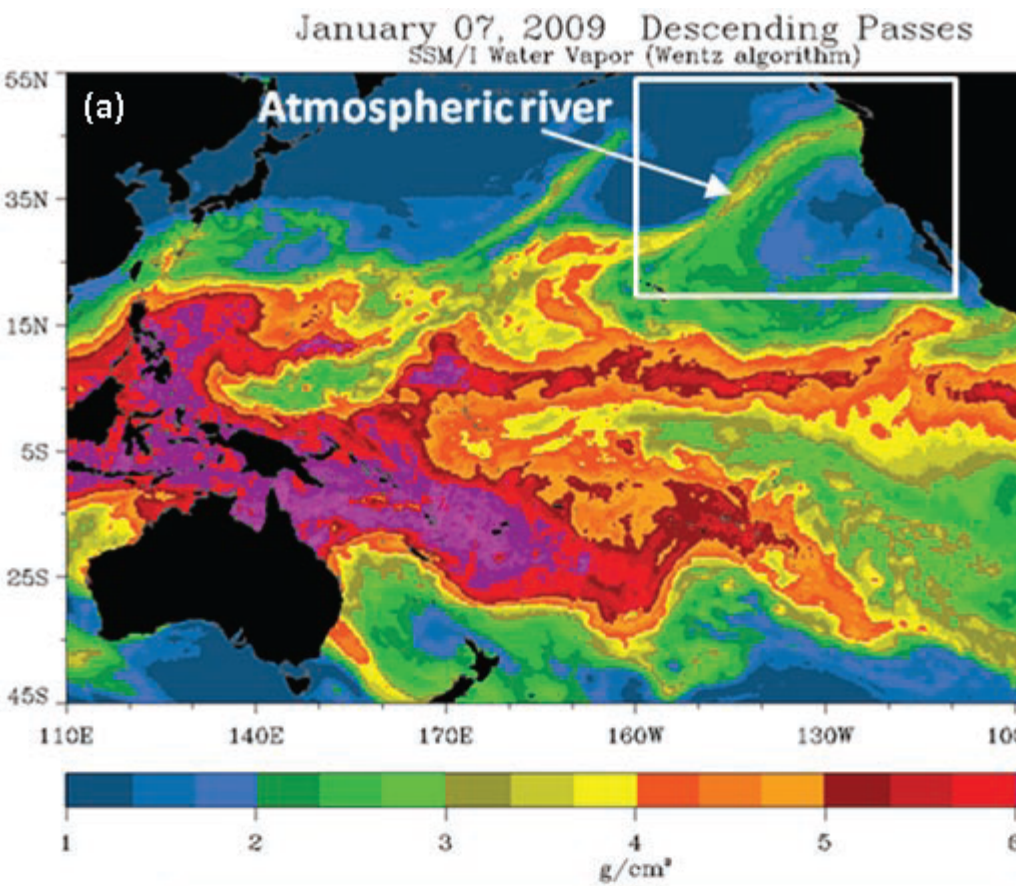
Forecasting Atmospheric Rivers

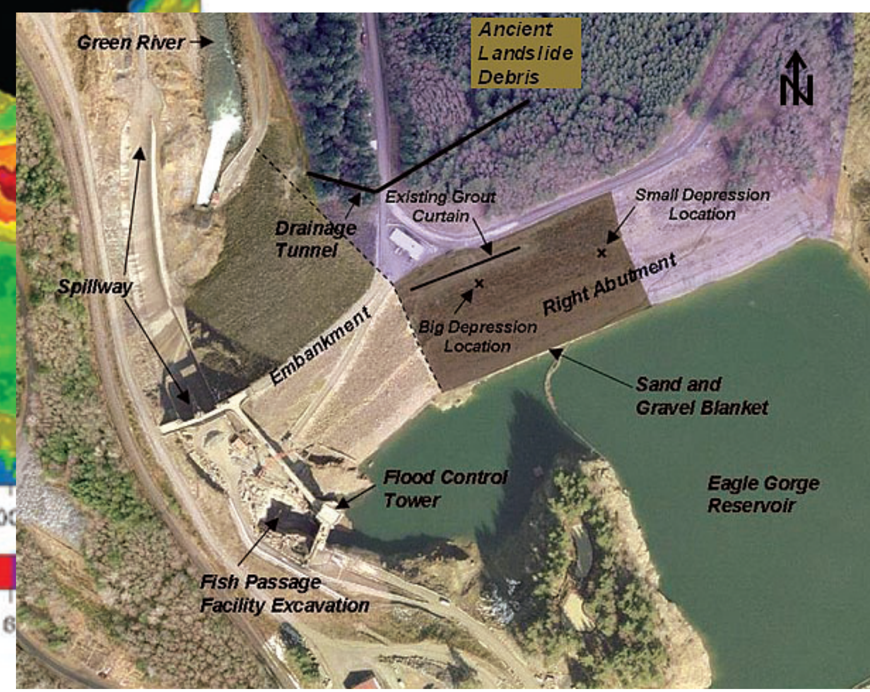
HMT Findings used in NWS Training



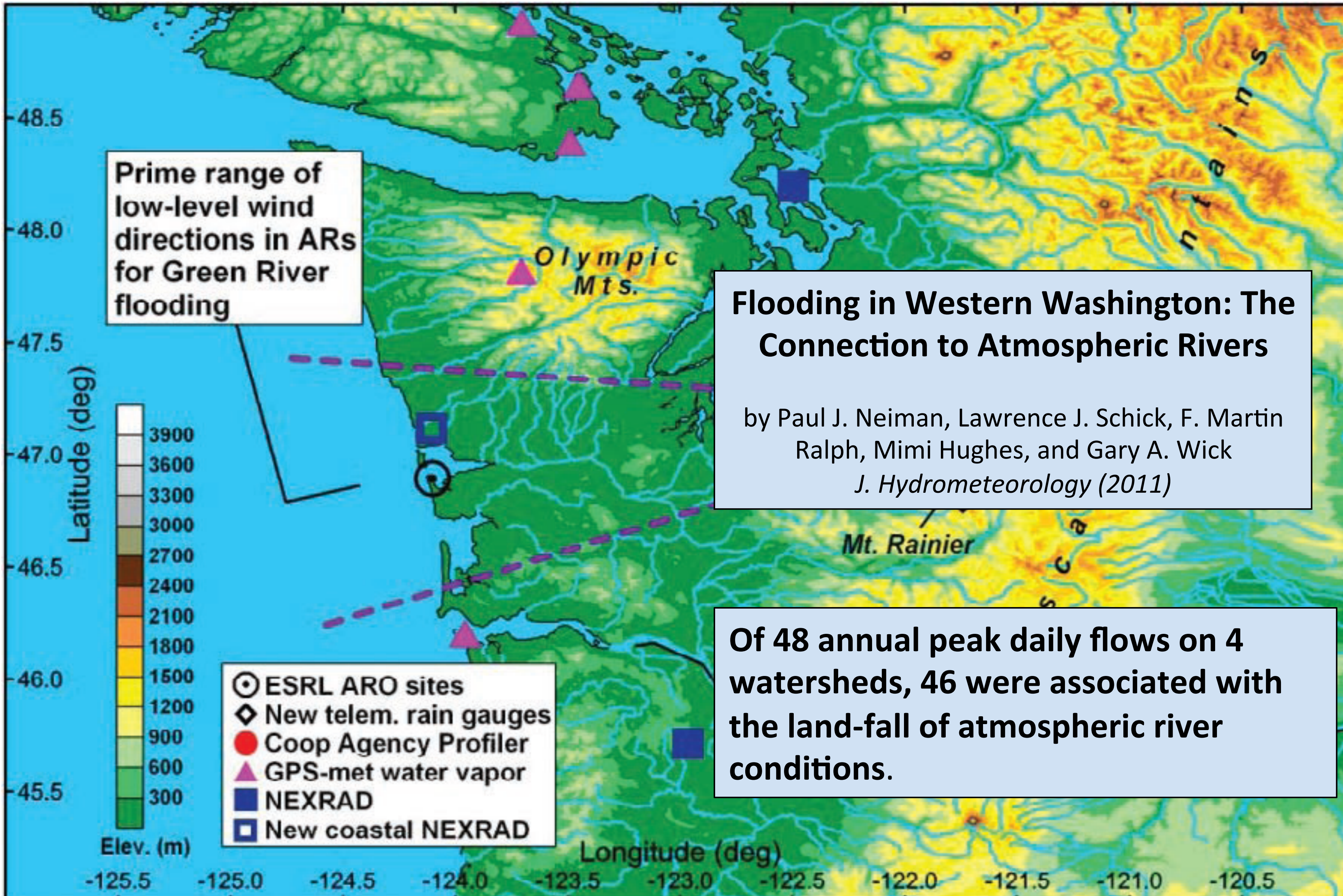
- Improved situational awareness
- Advance lead time that a "big event" may be coming, a few days ahead
- Details on locations, timing and strength improve as event nears, but precipitation amounts are generally underpredicted

Howard Hanson Dam Damaged by Storm in January 2007





NOAA/HMT Contributed new AR-related methods as part of a broad multi-agency rapid response



Flooding in Western Washington: The Connection to Atmospheric Rivers

by Paul J. Neiman, Lawrence J. Schick, F. Martin Ralph, Mimi Hughes, and Gary A. Wick
J. Hydrometeorology (2011)

Of 48 annual peak daily flows on 4 watersheds, 46 were associated with the land-fall of atmospheric river conditions.

This rapid response effort led to many lasting lessons, including demonstration of use of ARO data by the US Army Corps of Engineers (USACE)

NOAA'S RAPID RESPONSE TO THE HOWARD A. HANSON DAM FLOOD RISK MANAGEMENT CRISIS

by Allen B. White, Brad Colman, Gary M. Carter, F. Martin Ralph, Robert S. Webb, David G. Brandon, Clark W. King, Paul J. Neiman, Daniel J. Gottas, Isidora Jankov, Keith F. Brill, Yuejian Zhu, Kirby Cook, Henry E. Buehner, Harold Opitz, David W. Reynolds, and Lawrence J. Schick

NOAA operations and research personnel joined forces to better predict a possible flood and help calm public fears regarding reduced flood protection from a western Washington dam.

After nearly 50 years of service providing flood risk management for areas near Seattle, the U.S. Army Corps of Engineers (USACE) discovered signs of a potential dam failure at Howard A. Hanson Dam (HHD) after a potent winter storm in early January 2009. This dam safety issue increased the risk of catastrophic flooding in the now highly developed Green River Valley (GRV) downstream. As part of a broad set of actions by local, state, and federal agencies, the National Oceanic and Atmospheric Administration (NOAA) implemented a rapid response effort, coordinated between the National Weather Service (NWS) and the Office of Oceanic and Atmospheric Research (OAR), to enhance services to the communities at risk. These enhancements drew from ideas developed at NWS offices with inputs from regional stakeholders and took advantage of innovations in science and technology from NOAA's Hydrometeorology Testbed (HMT; Ralph et al. 2005a), which has focused on extreme precipitation events over the last several years (http://hmt.noaa.gov). This paper briefly describes the HHD and what happened to it,

AFFILIATIONS: White, Ralph, Webb, King, Neiman, and Gottas—NOAA/Earth System Research Laboratory/Physical Sciences Division, Boulder, Colorado; Colman, Cook, and Buehner—NOAA/National Weather Service/WFO Seattle, Seattle, Washington; Carter—NOAA/National Weather Service/Office of Hydrologic Development, Silver Spring, Maryland; Brandon—NOAA/National Weather Service/Western Region Hydrology and Climate Services, Salt Lake City, Utah; Jankov—Cooperative Institute for Research in the Atmosphere, Colorado State University, Fort Collins, and NOAA/Earth System Research Laboratory/Global Systems Division, Boulder, Colorado; Brill—NOAA/National Weather Service/Hydrometeorological Prediction Center, Suitland, Maryland; Zhu—NOAA/NWS/National Centers for Environmental Prediction/Environmental Modeling Center, Camp Springs, Maryland; Opitz—NOAA/National Weather Service/Pacific Northwest RFC, Portland, Oregon; Reynolds—NOAA/National Weather Service/WFO San Francisco Bay Area, Monterey, California; Schick—U.S. Army Corps of Engineers, Seattle, Washington
CORRESPONDING AUTHOR: Dr. Allen B. White, NOAA Earth System Research Laboratory R/PS2, 325 Broadway, Boulder, CO 80305
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The abstract for this article can be found in this issue, following the table of contents.

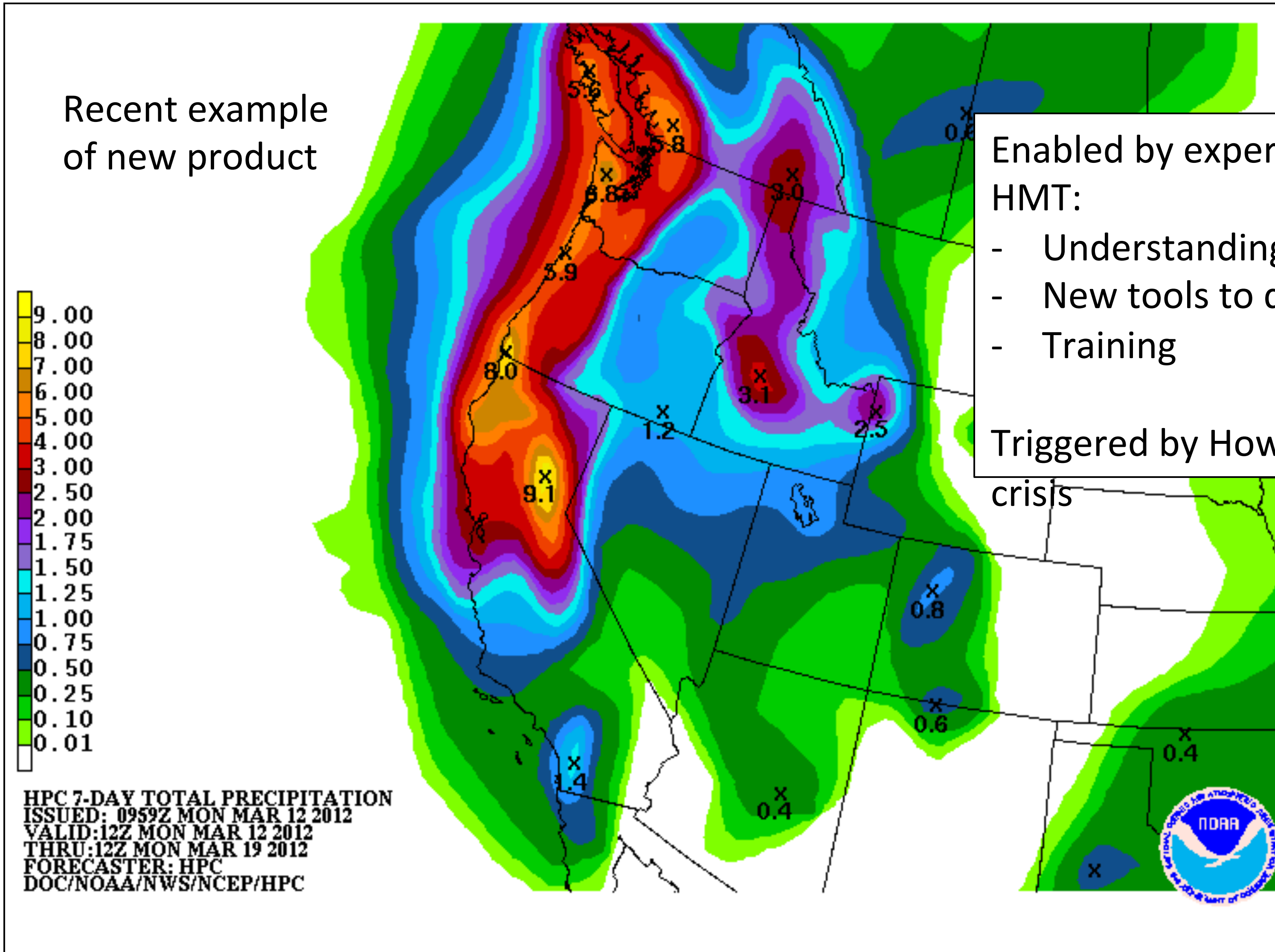
DOI:10.1175/BAMS-D-11-00103.1

In final form 5 July 2011

- USACE was considering taking over operation of a dam in Washington State during a recent storm.
- Using the HMT ARO at the coast and NWS forecasts, USACE saw the back edge of the AR was coming ashore and thus heavy rain was about to end, so they did not take over operation from the local water agency.
- See recent journal article by White et al. (February 2012; Bulletin of the American Meteorological Society).

HPC introduced new forecast product - 7-day QPF

Recent example of new product



Enabled by experiences from HMT:

- Understanding of ARs
- New tools to quantify ARs
- Training

Triggered by Howard Hanson Dam crisis

Quantitative Precipitation Estimation (QPE)

HMT QPE Plan

Coordinate QPE activities across HMT partner organizations

- Includes NOAA, NASA, and academic institutions

Develop strategy to deliver "best possible" QPE to NOAA's National Water Center

Three types of activities:

1) Baseline evaluations ("water now"): Multi-sensor Precipitation Estimator (MPE), National Mosaic and Multi-sensor QPE (NMQ) Q2, Mountain Mapper
2) Algorithm improvement ("water next"): Vertical Profile of Reflectivity (VPR), intelligent integration of radar, gauge, satellite, and model data, adaptive Z-R selection
3) Incorporation of next generation sensor technologies and design optimal networks ("water future"): Adaptive radar networks, observations system experiments (OSEs), etc

APPEND Strategy for QPE Activities

APPEND: AdaPtive Precipitation Estimation Network Design

- Evaluate QPE systems in different topographic/regional settings
- Improve understanding of sensor networks, modeling tools, data assimilation in current QPE systems
- “Smart” Integration of QPE from ground and satellite sensors as well as model QPF
- Platform for incorporating new algorithms and future technologies
- Design system to test new algorithms and future technologies
- Guide decisions for NWC about QPE forcing in complex terrain

HMT QPE Activities

- **Evaluate and improve radar QPE in CA watersheds**
  - In partnership with NSSL and Office of Hydrologic Development
  - Microphysical analysis leading to improvements in vertical profile of reflectivity correction and Z-R selection – American River Basin

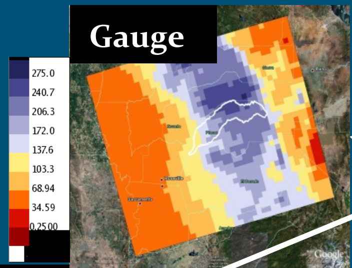
- **Assessment of QPE performance in Russian River Basin**
  - Evaluation includes spatial pattern and amounts
  - Impact of gap-fill radar to resulting QPE
  - In partnership with NSSL and OHD

- **Evaluation of radar QPE in Colorado Front Range**
  - Warm season convection
  - Performance of gap-fill radar QPE compared to NEXRAD
  - Sensitivity of radar QPE in distributed hydrologic model (in partnership with NCAR)
- **Evaluation and improvement of QPE in HMT-SE**
  - Assessment of NEXRAD dual-pol rain rate algorithm performance
  - Evaluation and improvement of QPE performance in upper Catawba basin

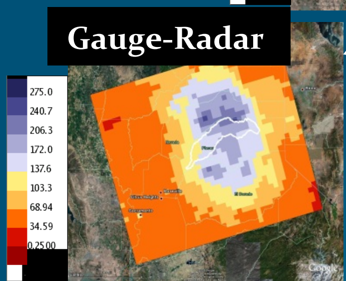
Assessment of Radar QPE in American River Basin

I. Problem: QPE dependent on input data

48-hr accum:
30 Dec 2005 –
1 Jan 2006



Which analysis is "correct"???



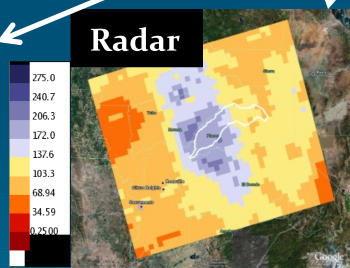
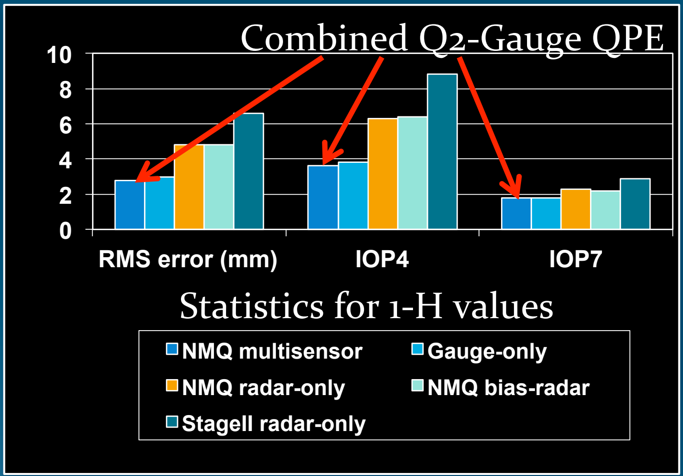


Image courtesy of D. Kitzmiller

III. QPE Analysis

RMS Error Statistics

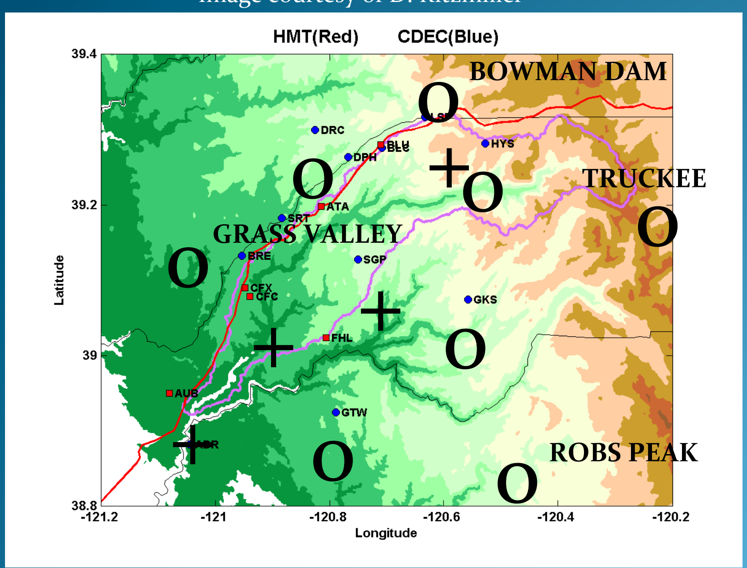


- Merged radar-gauge QPE shows best performance (RMS, CC, and bias)
- Results suggest that radar has a small, but positive impact on QPE in the ARB

Image courtesy of D. Kitzmiller

II. Methodology to Evaluate QPE Products

Image courtesy of D. Kitzmiller

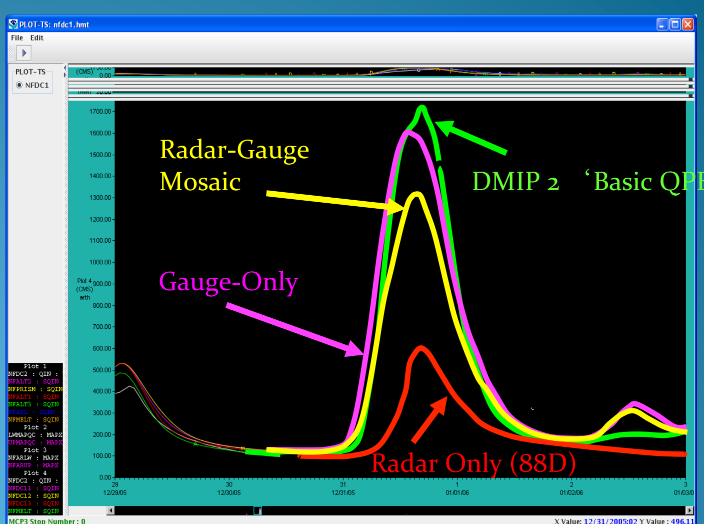


\+ REFERENCE GAUGE o INPUT GAUGE

- Input gauges include NCDC and CDEC
- References gauges are HMT and CDEC
- Input radar includes NMQ Q2 and Stage II
- All data input into MPE
- Compare QPE: gauge-only, radar-only, combined radar-gauge

IV. Impact on Hydrologic Runoff

Image courtesy of M. Smith



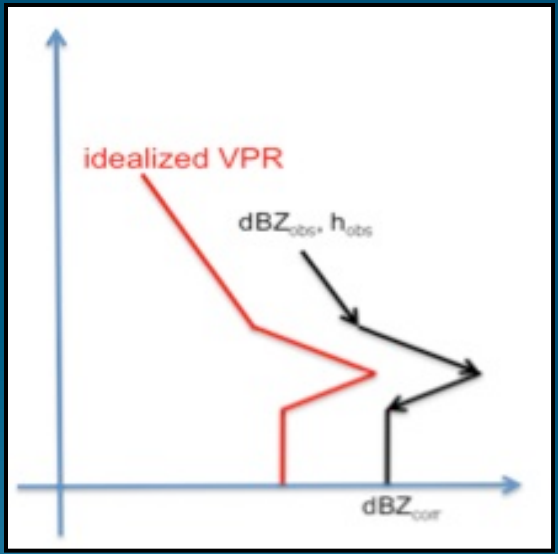
- Evaluate sensitivity of hydrologic model (HL-RDHM) to QPE
- All simulations predict peak runoff too early
- Combined radar-gauge QPE produces simulation that is closest to observed

Vertical Profile of Reflectivity Correction

I. HMT S-Prof Deployment

- high resolution observations of vertical structure of precipitation

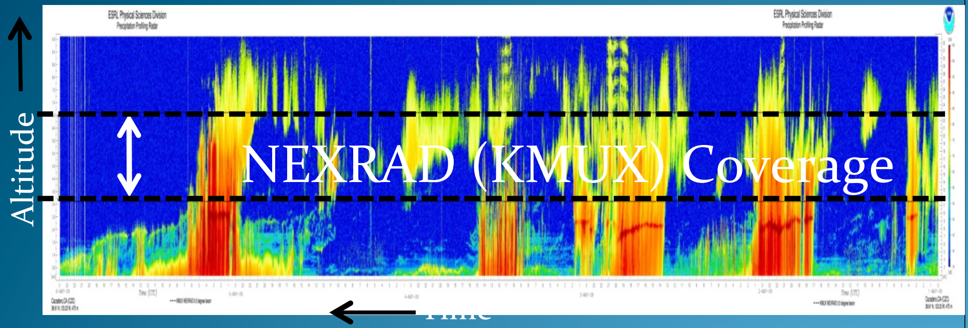
III. VPR Correction



- S-Prof observations used to provide a realistic VPR correction

II. S-Prof Observations

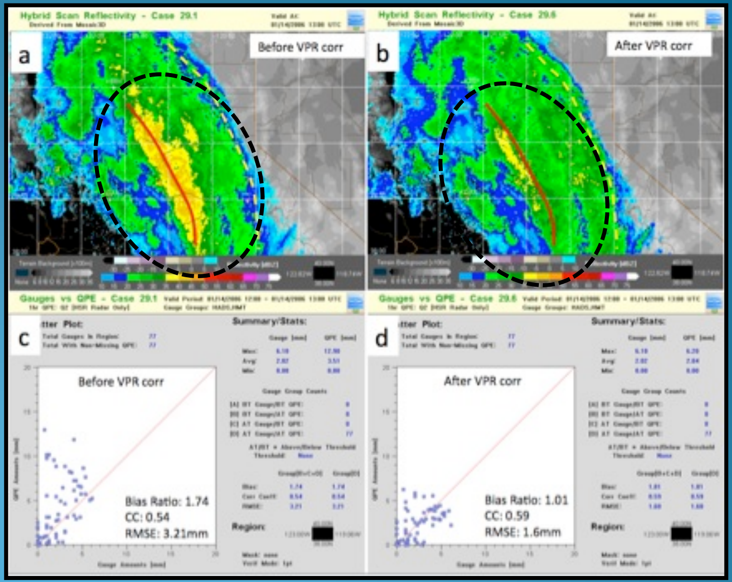
Cazadero S-Prof and KMUX



- S-Prof captures precipitation variability at low levels that is often missed by operational scanning radar

IV. VPR Correction Applied to NMQ Q2

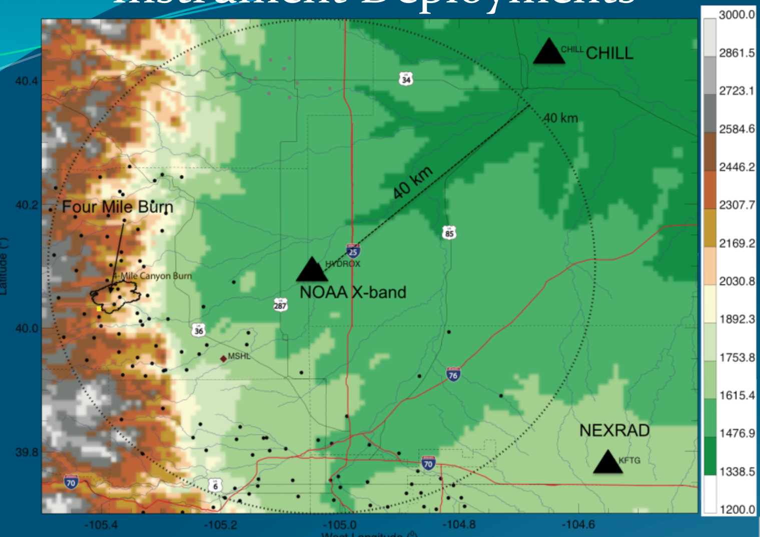
No VPR Correction With VPR Correction

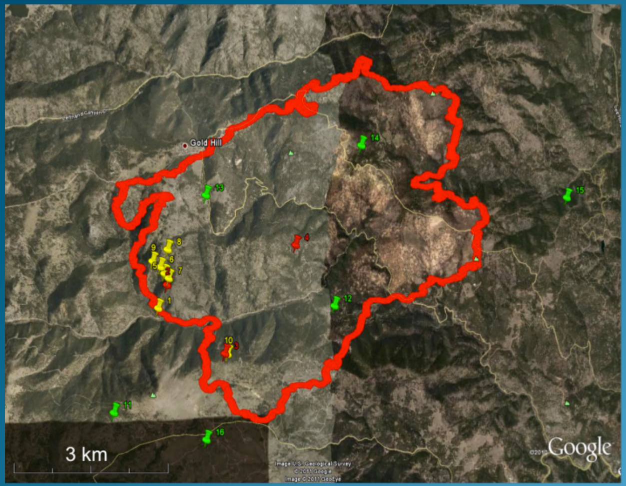


- VPR correction improves QPE
- VPR correction technique to applied CONUS in NMQ Q2

Four Mile Canyon: Assessment of Gap Filling Radar for QPE

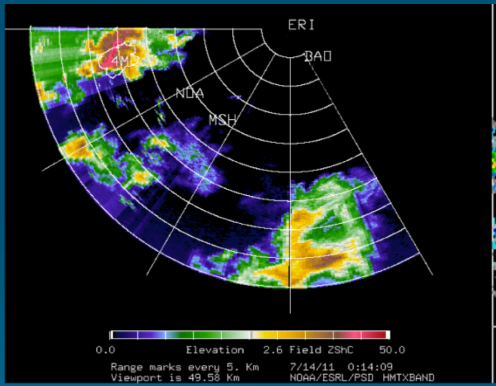
Instrument Deployments



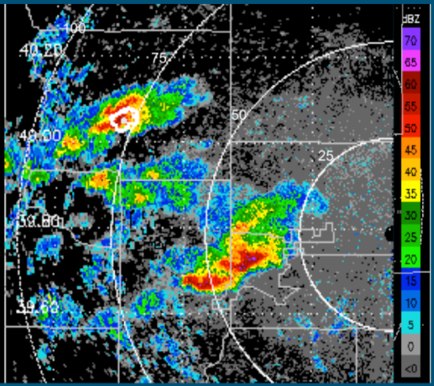


Perimeter of Fourmile Canyon burn area with location of rain gauges indicated by colored pins. Green, yellow, and red colors correspond to ALERT, USGS, and NCAR gauges, respectively.

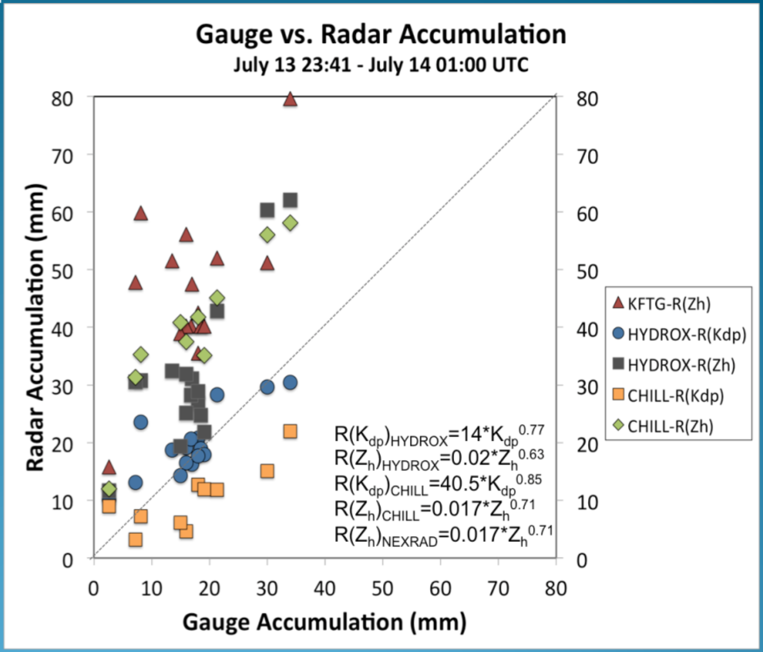
Radar Observations



NOAA X-band



KFTG NEXRAD

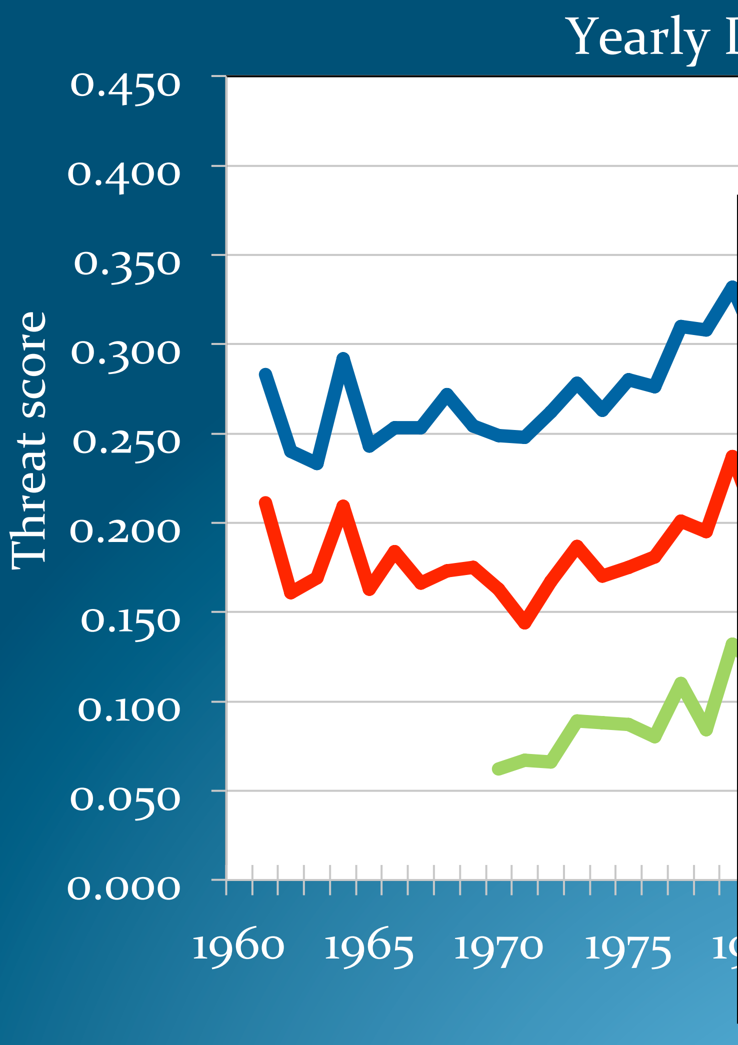


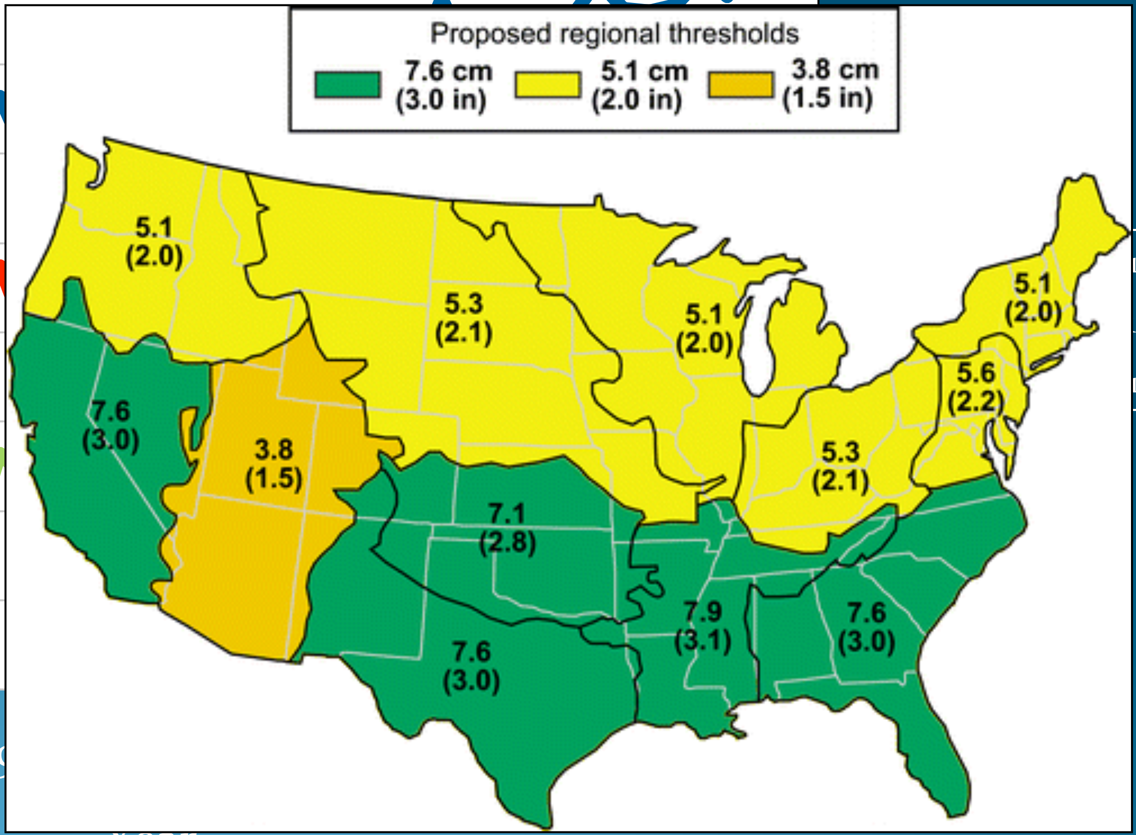
Results

- X-band captures amount and spatial variability
- Next step to assess impact of QPE on runoff

Quantitative Precipitation Forecasting (QPF)

How are QPFs monitored?





HMT QPF

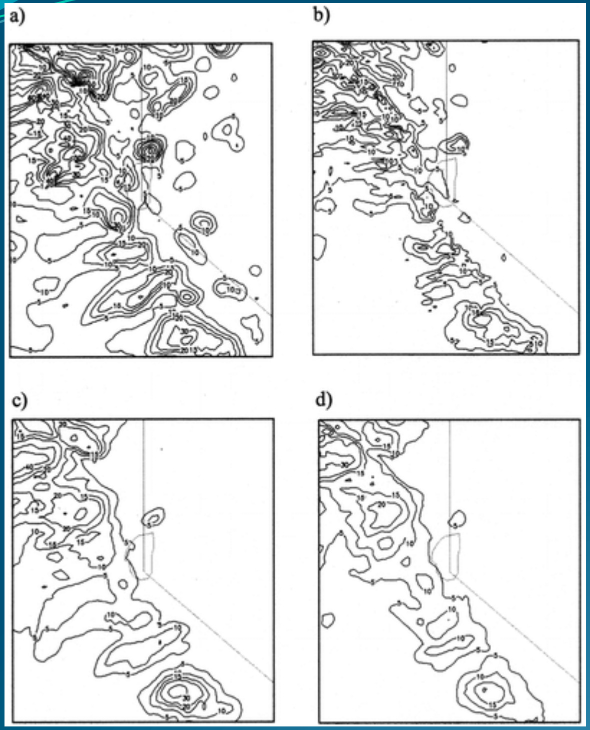
Mission:

To improve QPF/PQPFs and establish a framework to translate these advancements into improved NWS precipitation and hydrologic forecasts.

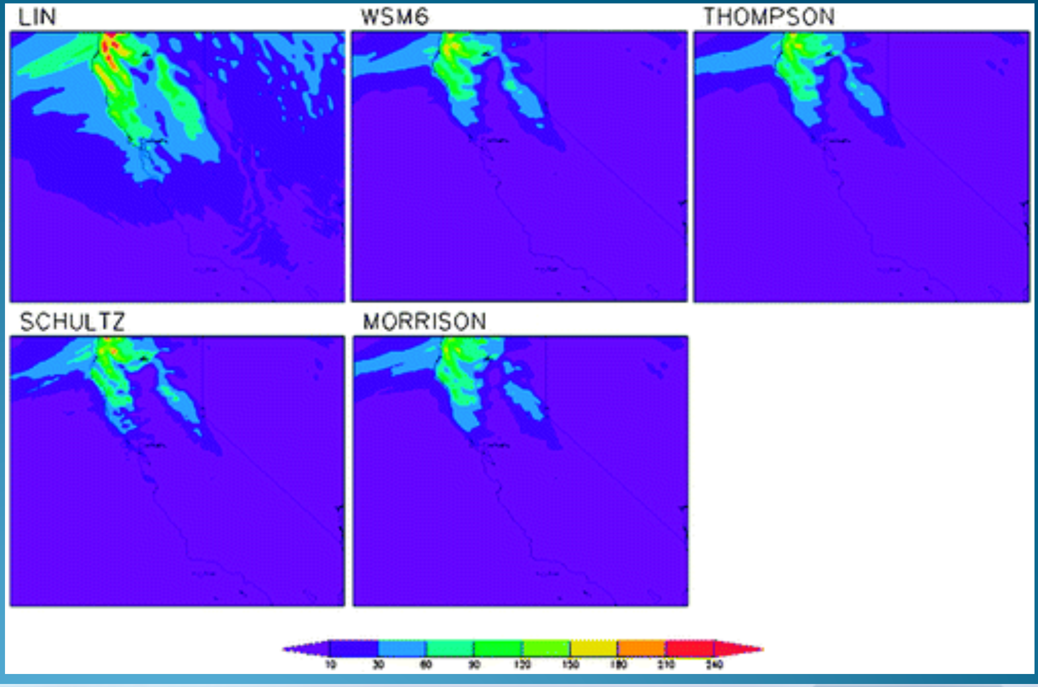
Objectives:

- Develop new downscaling and post processing techniques
- Establish new observation systems and techniques
- Improve physics parameterizations and initialization of numerical weather prediction models
- Develop ensemble-based PQPF techniques
- Improve the understanding of dynamical and physical processes responsible for rare but heavy and frequent but moderate precipitation events
- Develop new long-range forecasting techniques
- Explore traditional (e.g., skill scores) and non-traditional (e.g., object-oriented) verification methods and techniques
- Develop ways to infuse new technologies into NOAA operations.

Select HMT QPF Results



- An HMT-ensemble system was developed for the HMT-West domain and accumulated rainfall in the domain has been simulated.



- Multiple microphysics schemes have been analyzed to simulate accumulated precipitation.

2012 HMT QPF Activities

- Develop experimental real-time national ensemble (~10 km)
- Validate microphysics of EMC and WRF model output
- Baseline extreme QPF performance over CONUS
- Develop spatial verification techniques for
  - HPC 32-km gridded QPF (CONUS)
  - Atmospheric rivers (West Coast)
- Determine moisture sources & methods of transport in SE U.S.
- Analyze reforecast QPF performance for AR events
- Conduct forecasting experiments (NOAA HMT-HPC)
  - Winter Weather Experiment
  - Spring Experiment in the Hazardous Weather Testbed
  - AR Retrospective Forecasting Experiment

NOAA HMT – HPC

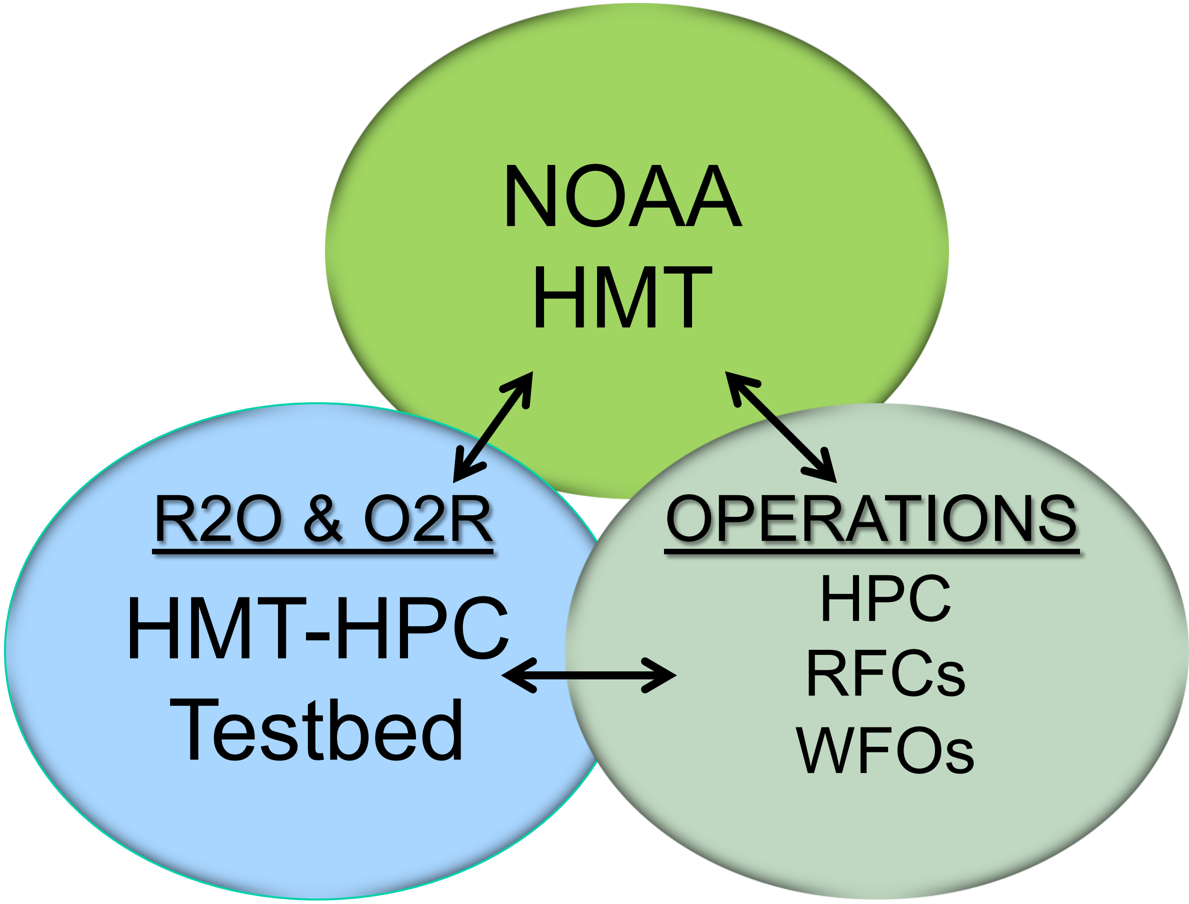
Description

A component of the NOAA HMT

Goal: Transfer science and technology innovations into operations to improve prediction of heavy precipitation

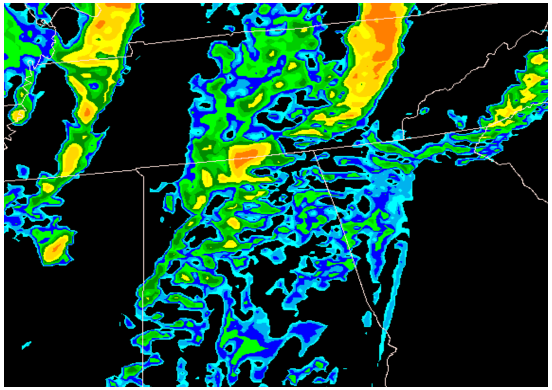
Roles:

- Identify and test new datasets to improve HPC forecasts
- Develop forecaster-relevant tools/techniques
- Provide training in new techniques to forecasters & researchers

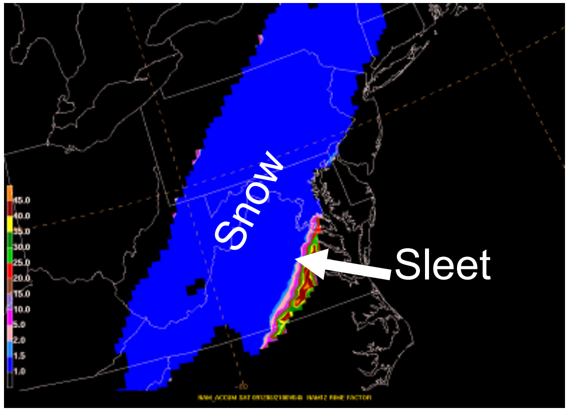


Experiments

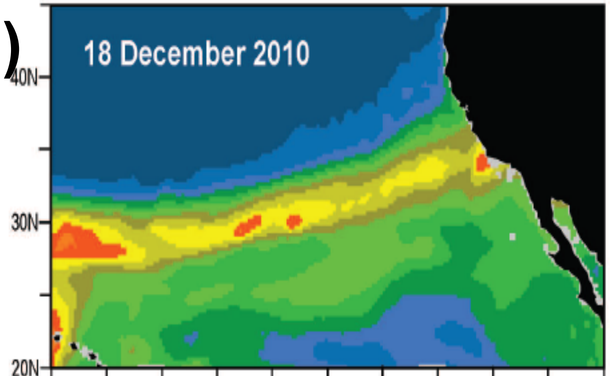
QPF Component of Spring Experiment
Focus: Warm-season convection
Datasets: Convection-allowing deterministic and ensemble guidance
Lead Time: 0-36 hours



Winter Weather Experiment
Focus: Assess & communicate uncertainty
Datasets: Convection-allowing deterministic and ensemble guidance
Lead Time: 36-72 hours



Atmospheric Rivers Experiment (Fall 2012)
Focus: Precipitation amounts and timing
Datasets: High-res models and reforecasts
Lead Time: 1-7 days

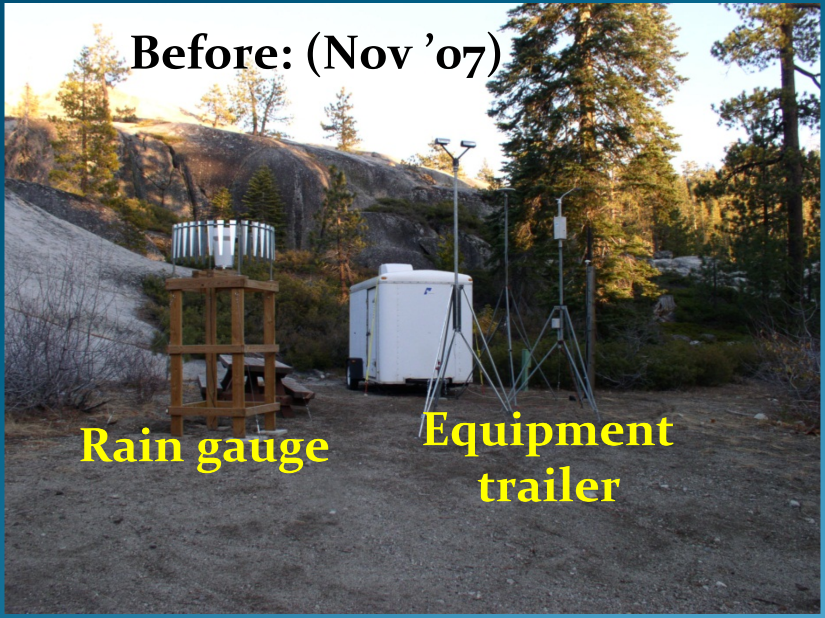


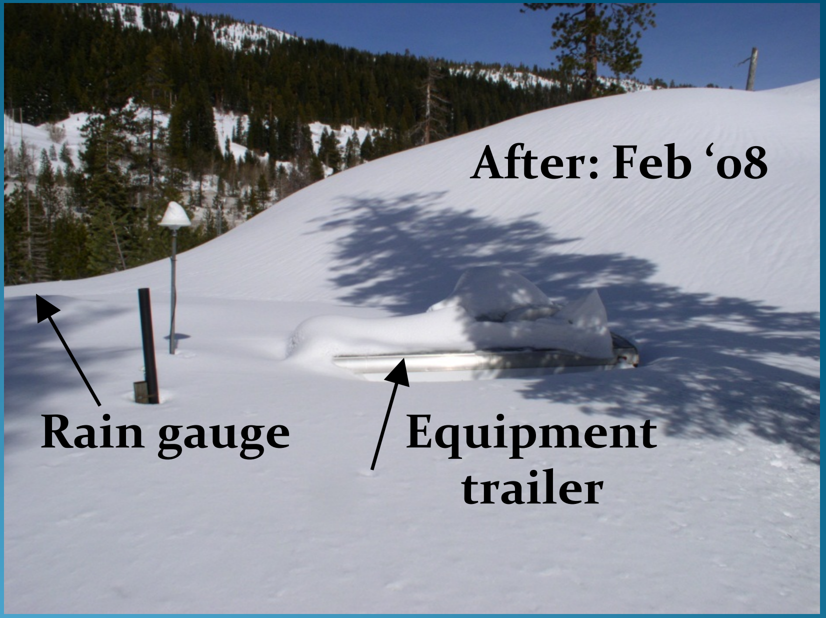
Snow Information

HMT MAA: Snow Information

Major sub-themes in this activity presently include:

- Snow Depth and Snow Information
- Snow Level and Freezing Level Observations

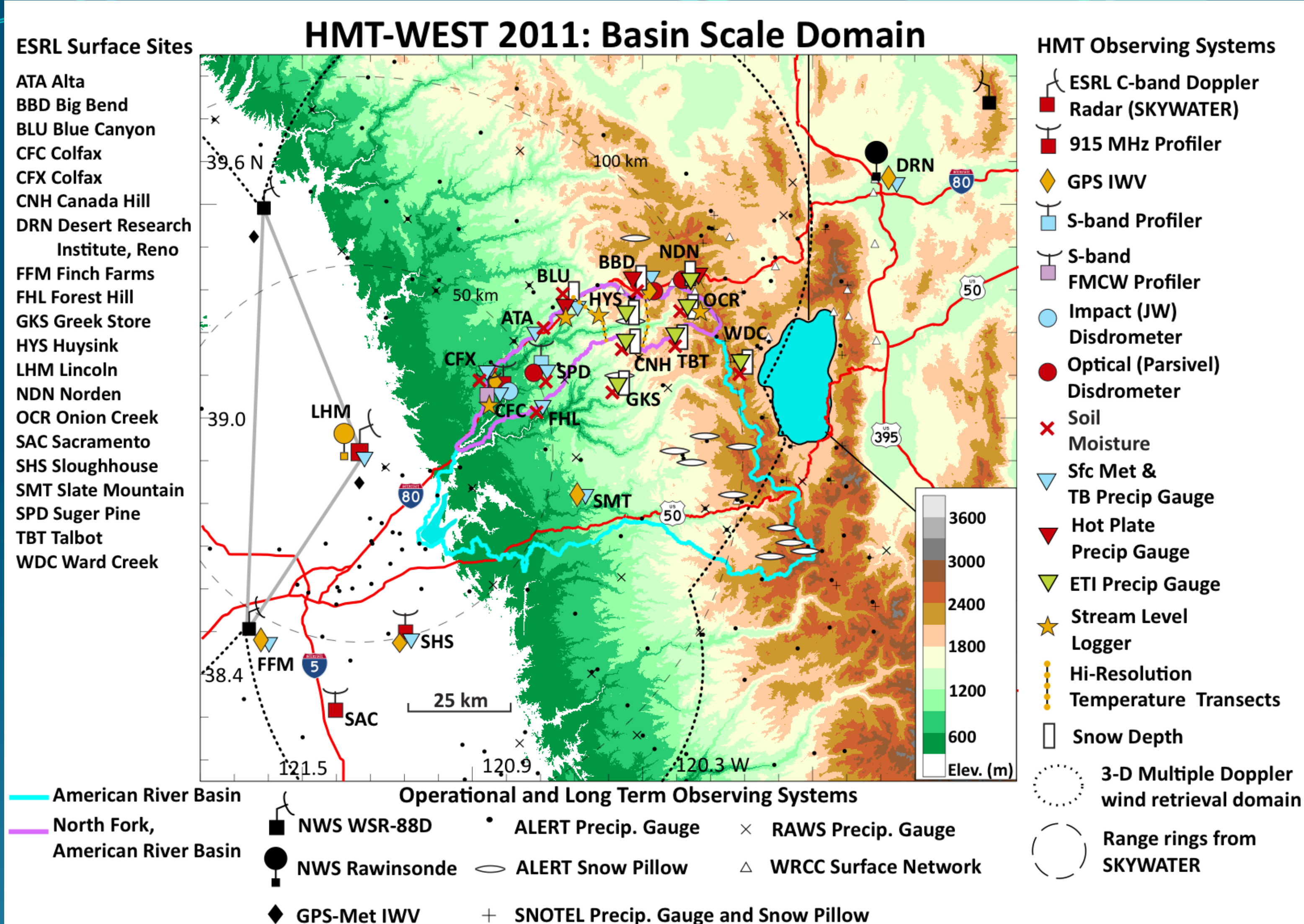




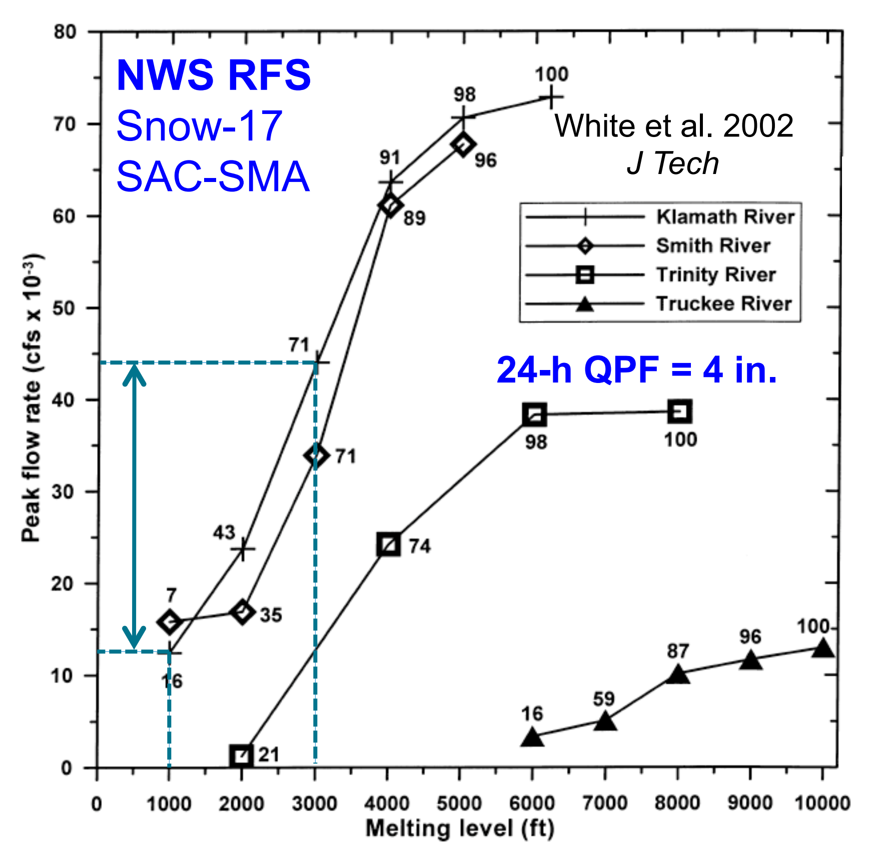
HMT Snow Information Activities

- Continued operation and maintenance of HMT snow and precipitation gauge network in the American River Basin
- Expansion of Snow-level Radar network in California to ten sites
- Washington snow-level forecast performance analysis and publication
- Expansion of California SL forecast performance analysis
- Blending of snow-level observations and numerical weather prediction analyses to produce a continuous in time snow-level product
- Outreach to expand SLR network to the Pacific Northwest

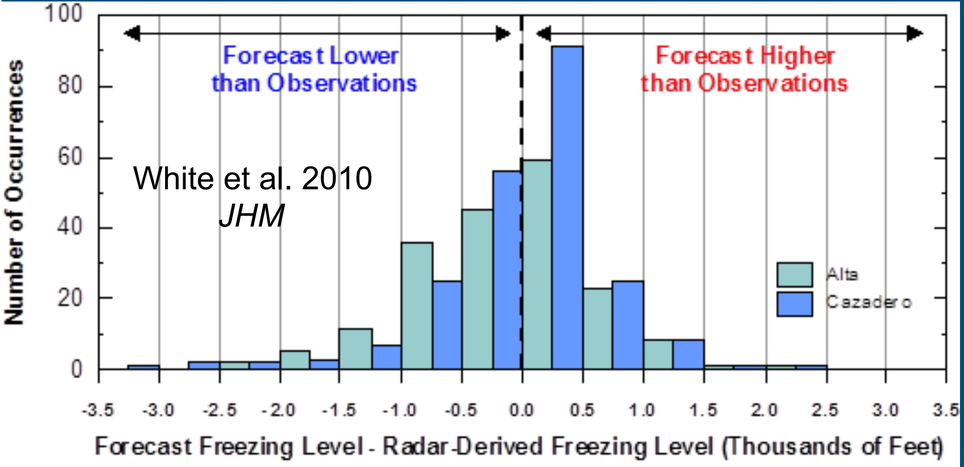
HMT Instrumentation in the North Fork of the American River Basin



HMT Snow-level Research Results



Flow in mountainous watersheds in sensitive to the snow level



Snow-level forecast performance

Hydrologic and Surface Processes

GOALS

- Address hydrologic scientific questions and forecast operations implications
- Inform IWRSS National Water Center on hydrologic modeling and decision support

HASP OBJECTIVES

- Conduct distributed modeling using high resolution precipitation fields
- Primary model is the HL-RDHM - other models may be used as appropriate
- Candidate basins:

  Russian–Napa Rivers, CA; Babocomari River, AZ; N. Fork American River, CA
- Parameter sensitivity, parameter identification, calibration and verification activities
- Compare the distributed model results with those obtained from the lumped model
- Apply versions of QPE and QPF hi-res precipitation fields
- Examine soil moisture and ET dynamics and the role of in-situ measurements
- Apply WRF ensemble for selected rainfall events
- Characterize range of uncertainty associated with the various hydromet forcings
- Determine what measurements of precipitation, soil moisture, evapotranspiration, and stream flow are most critical for accurate hydrological modeling
- Examine scalability issues of distributed hydrologic input data and modeling in support of IWRSS-NWC

Russian River Basin

Goals

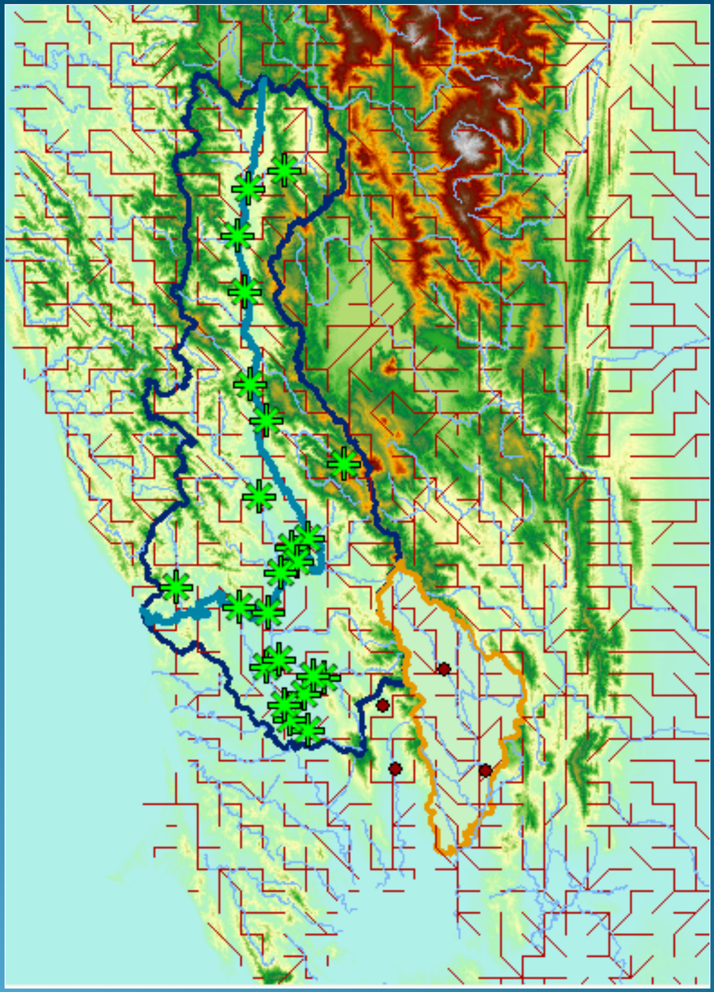
- More forecast points
  - Tributary flows
- QPE / QPF
- Soil moisture
- Uncertainty

Assess lumped vs distributed model

- CNRFC forcings and lumped model outputs
- Compare to national hydro model

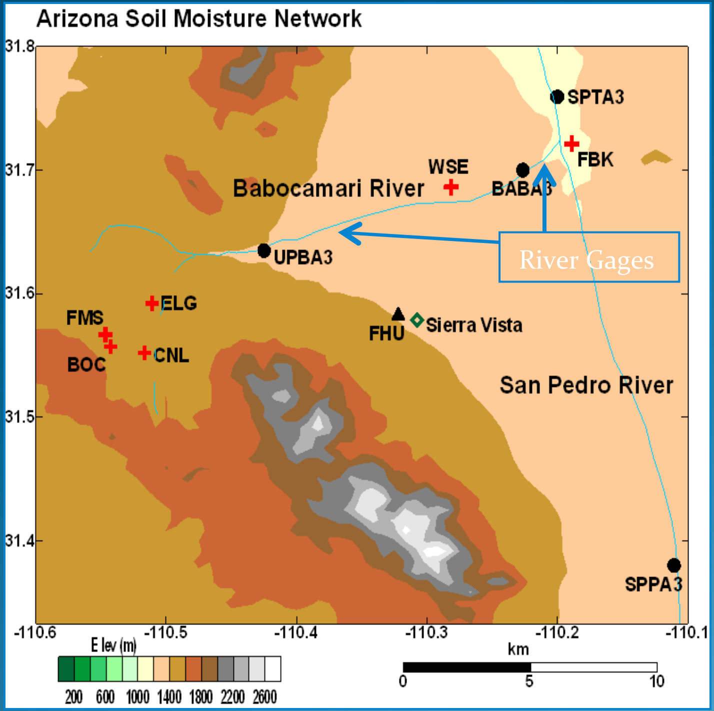
IWRSS Demonstration

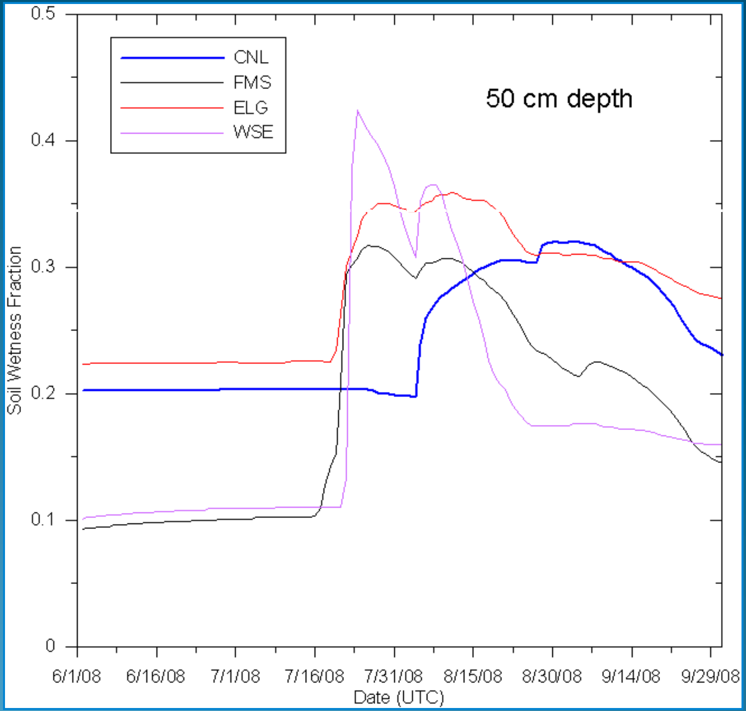
- Stakeholder involvement
- Monitoring
- Assimilation / Analysis
- Prediction
- System Integration and Decision Support
- Assessment of benefits



SOIL MOISTURE

22 July 2008 rainfall brought the soil column to wetness values exceeding field capacity; setting the stage for the flood observed 23 July in the lower basin*





*Zamora, R. et al. 2009: The NOAA Hydrometeorology Testbed Soil Moisture Observing Networks: Design, Instrumentation, and Preliminary Results. J. Hydromet. October.

Emerging Directions

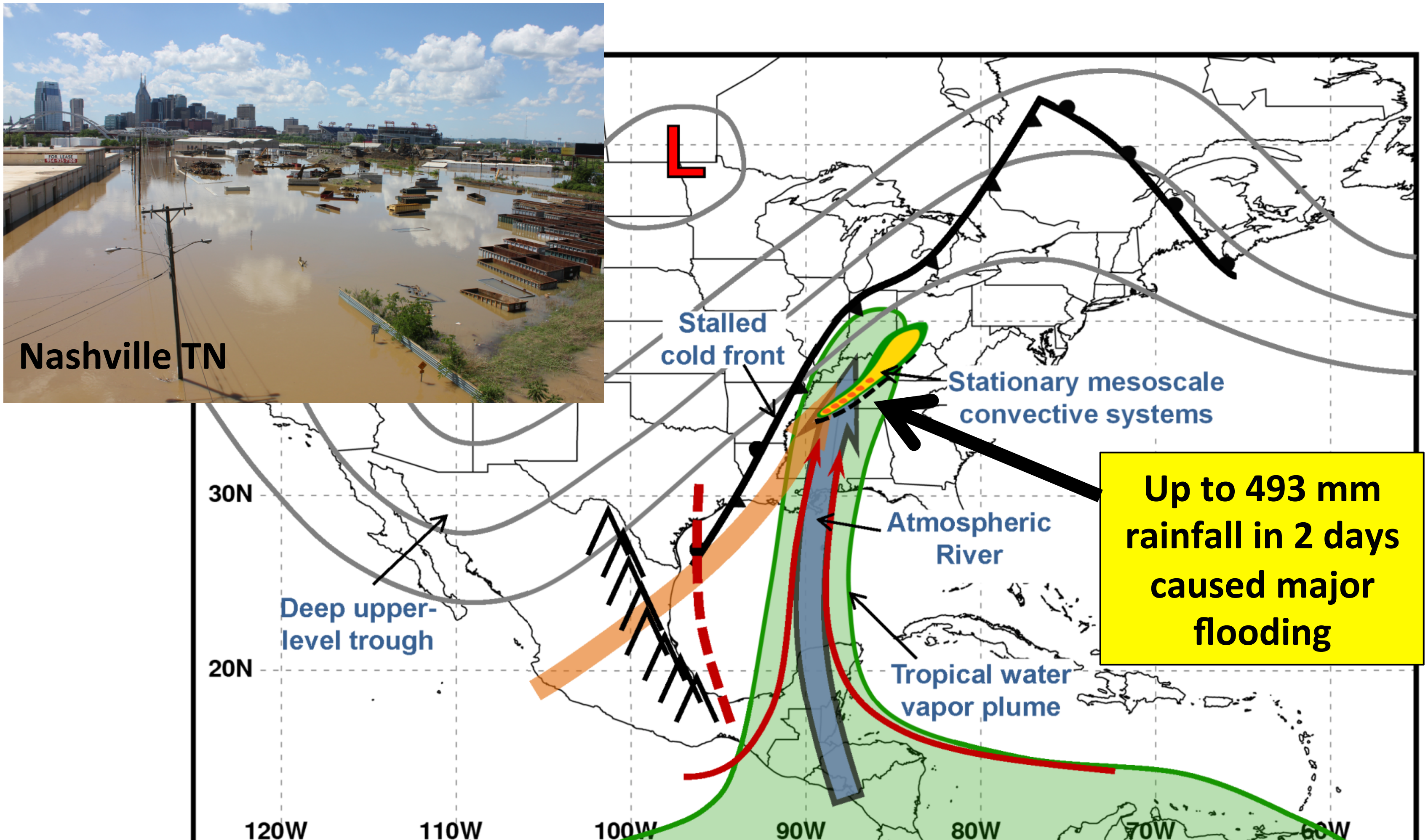
HMT-SE Pilot Study (HMT-SEPS)

- HMT-SEPS is pilot project in western NC
  - Primary focus is Upper Catawba watershed near Asheville
  - 2ndary focus is coastal region
- Project duration is May 2013 – April 2015
  - Instrument deployments May 2013-Spetmeber 2014
- Involve close coordination with NASA GPM GV
  - QPE is big driver for both GPM GV and HMT-SEPS
  - GPM GV will have intensive field campaign May-June 2014 in same region
- Major focus of HMT-SEPS is QPE and QPF
  - Profiler DSD retrievals / partition profiler data
  - NEXRAD DSD retrieval/RR comparisons
  - Integration/evaluation of QPE in NMQ/MPE
  - Extreme precipitation climatology correlated to moisture sources/transport
  - Process studies

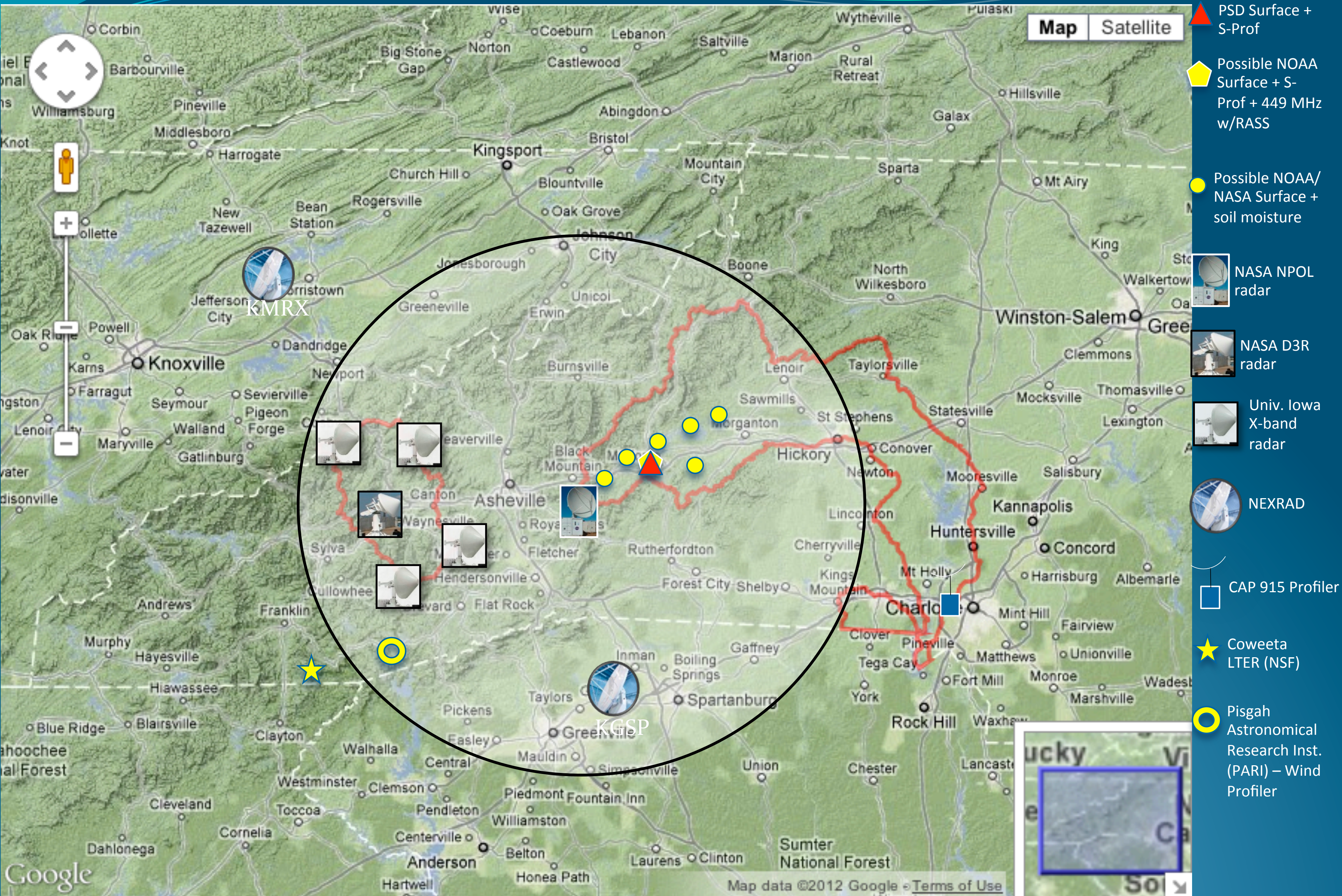
Physical Processes Associated with Heavy Flooding Rainfall in Nashville, Tennessee, and Vicinity during 1–2 May 2010: The Role of an Atmospheric River and Mesoscale Convective Systems

Ben Moore, Paul Neiman, Marty Ralph, Faye Barthold

Monthly Weather Review (2012)



HMT-SEPS Basin Scale Map



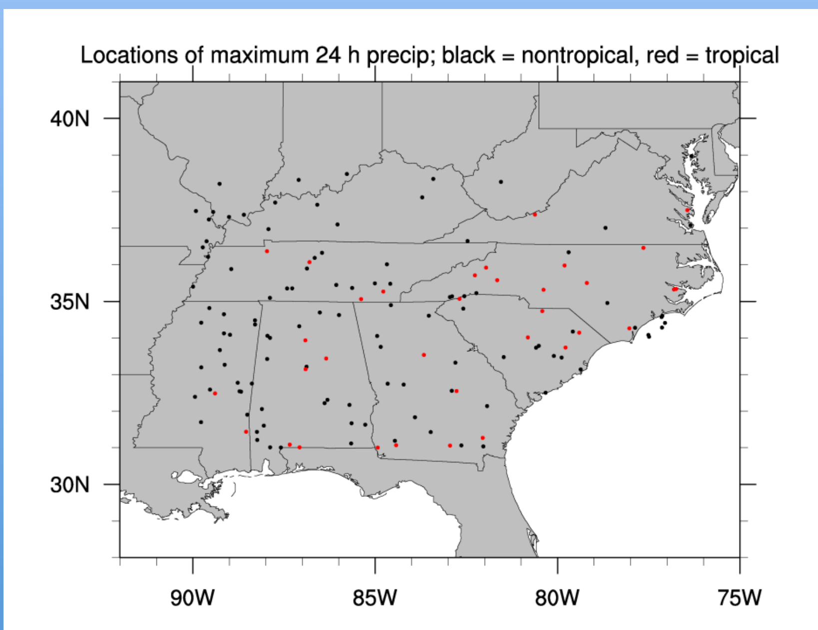
HMT-SE early research: Extreme precipitation

- What is the climatology of extreme precipitation events in the southeast U.S.?
- How do QPF errors relate to the largest observed precipitation events?
- What are the primary moisture sources and moisture transport mechanisms for extreme rainfall in the southeast U.S.?

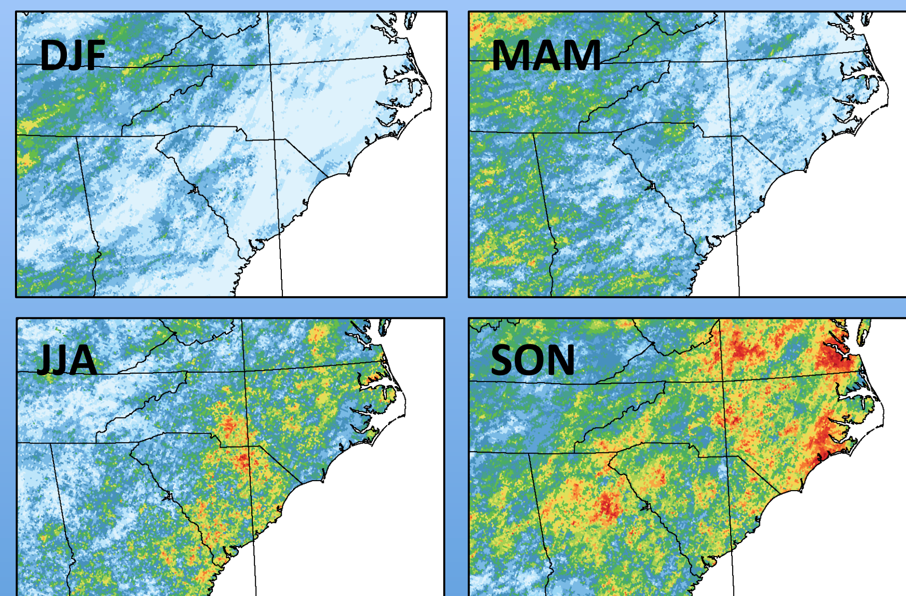
Climatology of extreme precipitation in southeast U.S.

Data source:
4-km NCEP Stage-IV radar and multi-sensor precipitation analysis

Methodology:
Define extreme events by 99th percentile of wet days (per gridpoint)



Seasonality of extremes:
*Frequency of extreme precip days in each season displayed as a **percent** of the total number of extreme precip days over the entire 10-y period*



Southeast U.S. experiences extreme rainfall over all seasons

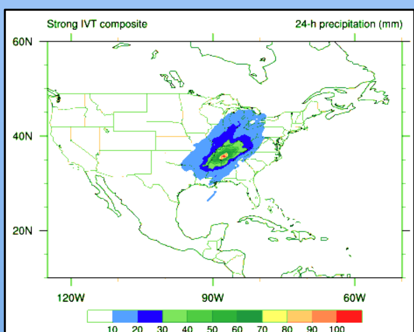
(Ben Moore)

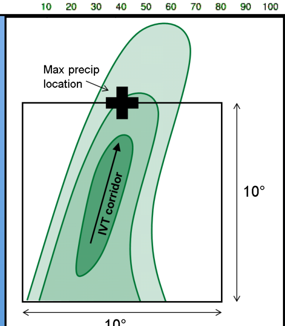
HMT-SE early research: Extreme precipitation

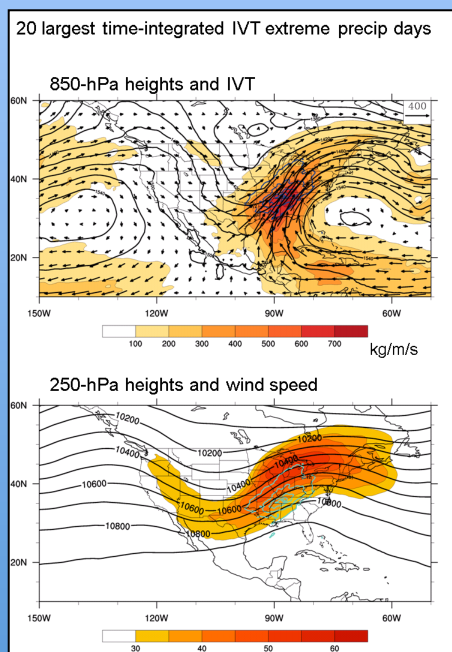
- What is the climatology of extreme precipitation events in the southeast U.S.?
- How do QPF errors relate to the largest observed precipitation events?
- What are the primary moisture sources and moisture transport mechanisms for extreme rainfall in the southeast U.S.?

Extreme event composite research

Example: How does intensity, direction of strongest moisture transport relate to precip amount, other predictors?





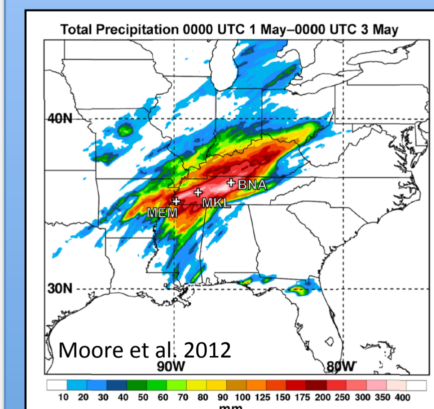


Composite fields based on strongest southerly IVT over all of southeast

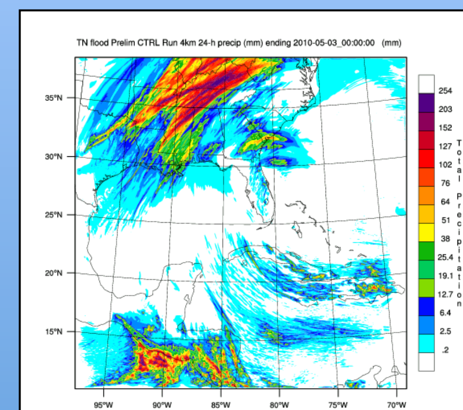
Case study analysis and model-based experiments

Example: Use WRF to simulate observed cases and composites: test hypotheses (e.g., roles of moisture sources, terrain impacts)

TN floods: May 2010



Observed precipitation



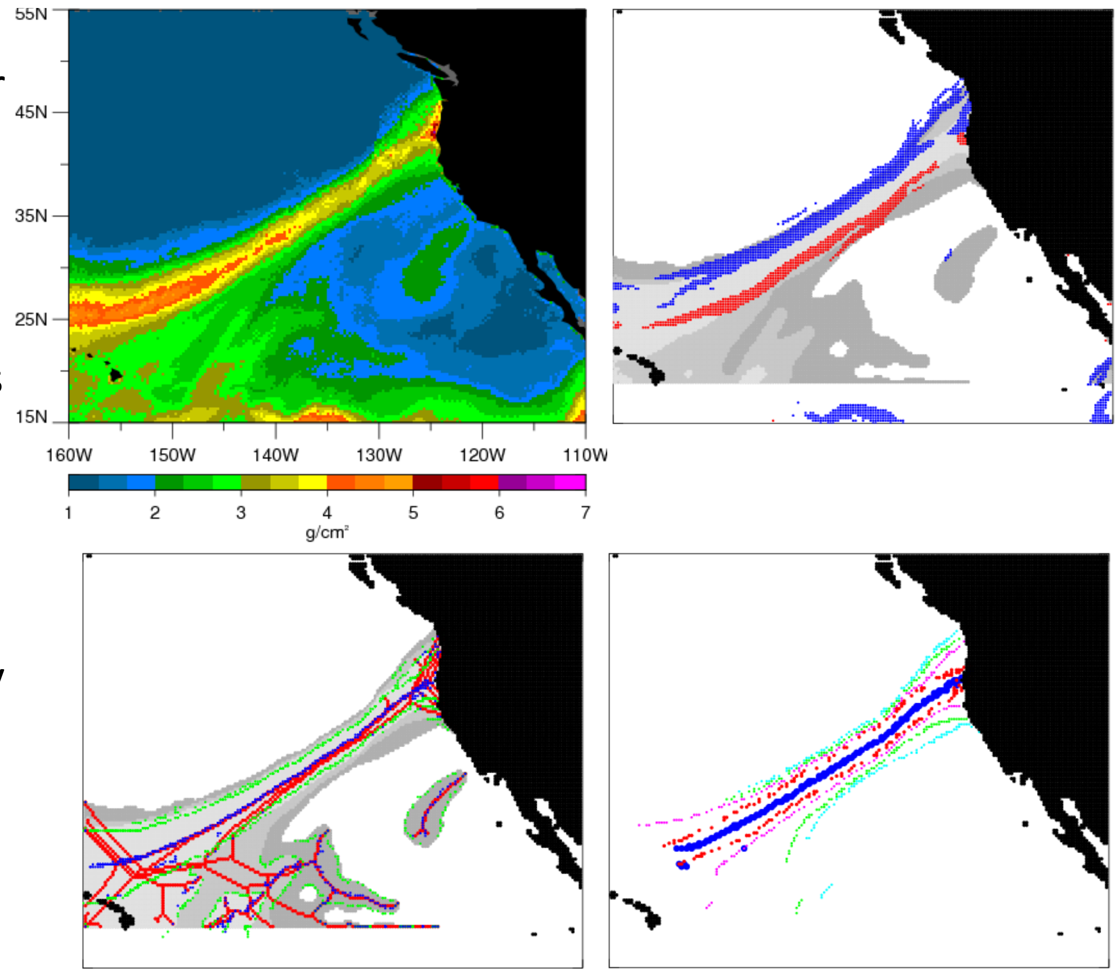
WRF-simulated precipitation

WRF model run using 4-km gridspacing, explicit convection, and CFSR initial conditions: closely matches observed heavy rainfall

Please see HMT-SE Poster (Mahoney et al. , 2:20pm Wednesday 5/2) for more information

Objective AR Identification Procedure

- Isolate top of the tropical water vapor reservoir
- Threshold IWV values at multiple levels and compute gradients
- Cluster points above thresholds and compute skeleton to estimate axis
- Identify points satisfying width criteria
- Cluster center points to identify segments of sufficient length
- Extract AR characteristics
- Determine if AR intersects land or is potentially influenced by data gaps

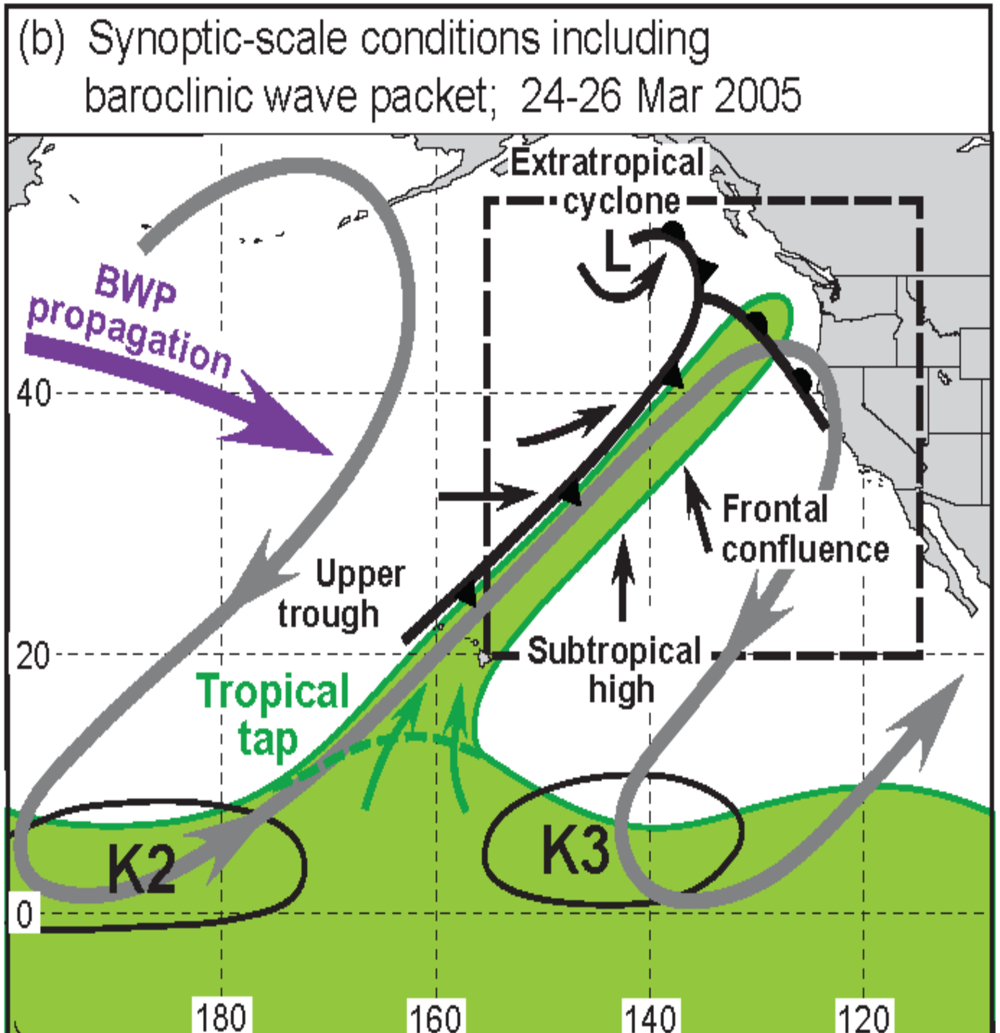


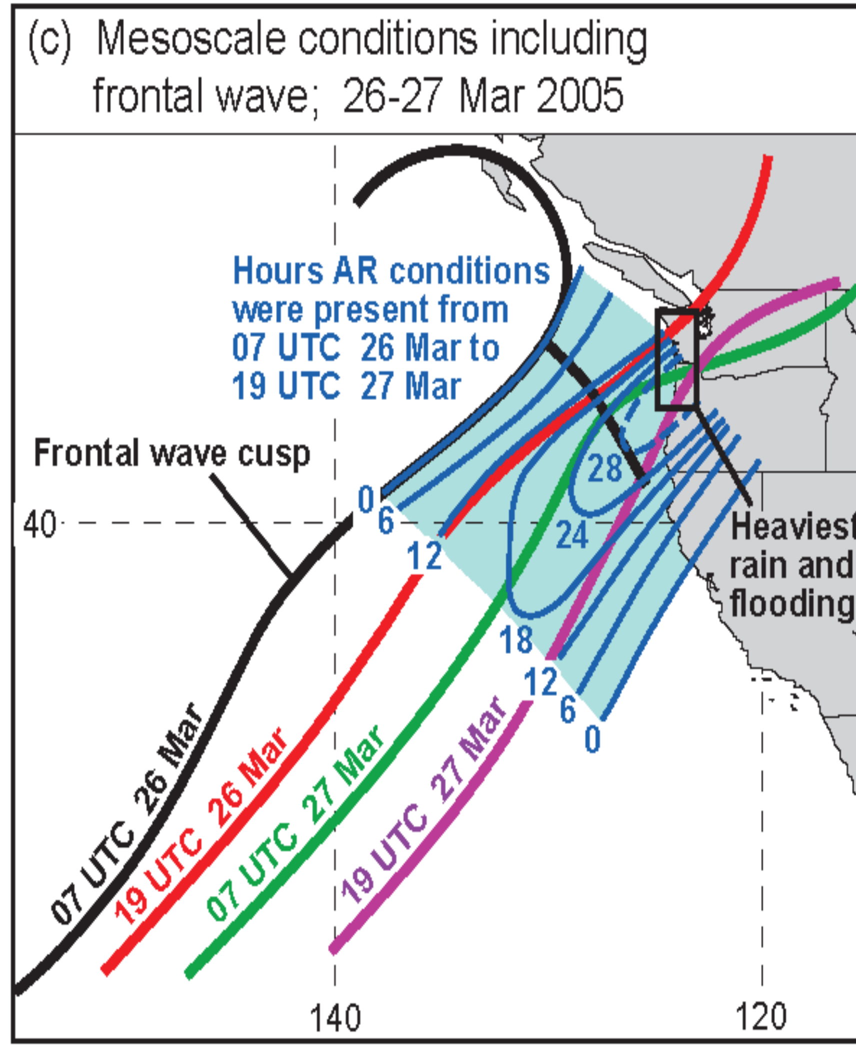
Example from November 7, 2006

Wick et al., 2012, IEEE TGRS, in revision.

Phasing of tropical and extratropical conditions leading to entrainment of tropical water vapor into the AR

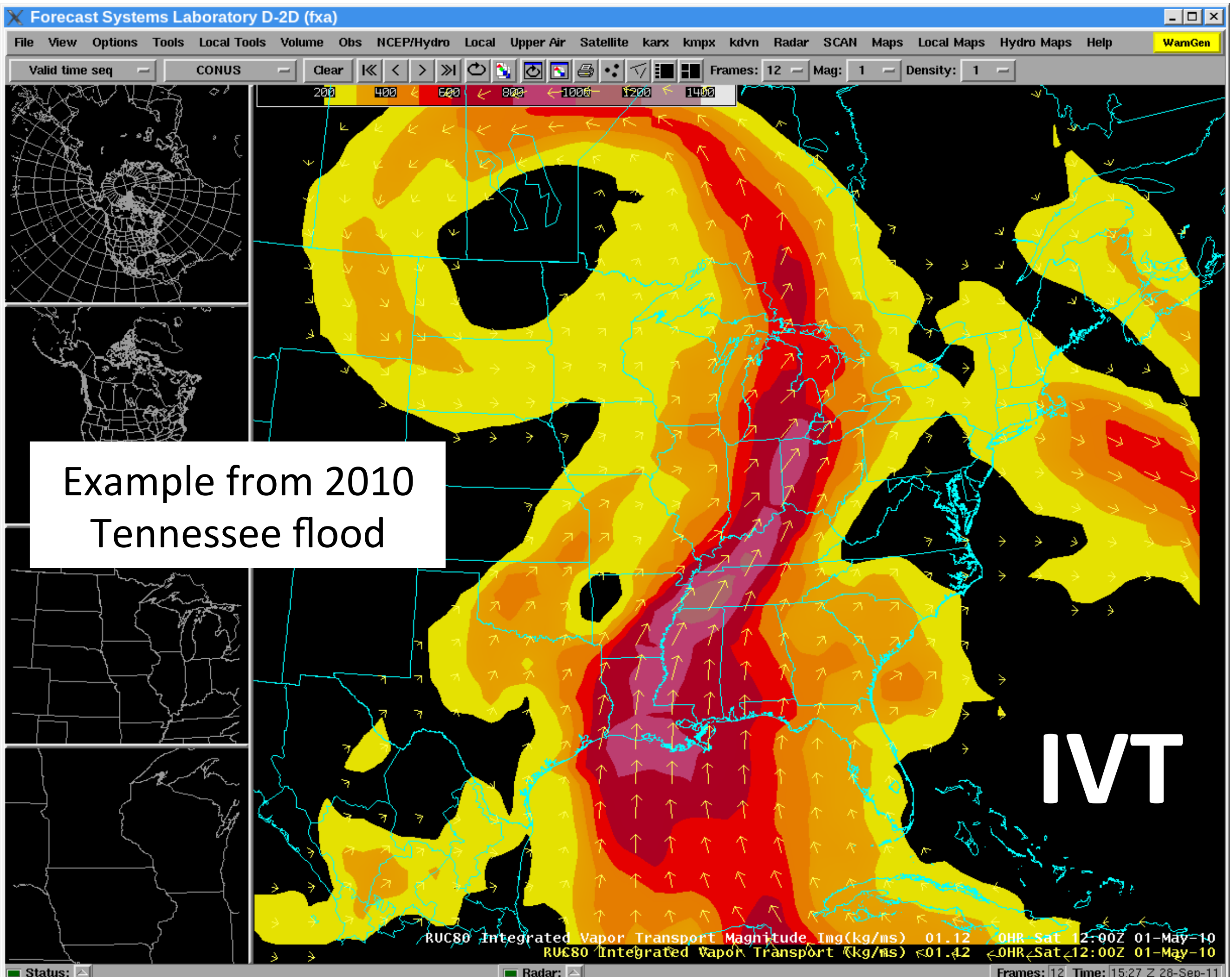
The frontal wave increased the duration of AR conditions where the extreme precipitation occured





Vertically Integrated Vapor Transport (IVT)

A key variable is the vertical integral of the horizontal water vapor transport – called "IVT"



Observations of IVT are available from profiling systems, including dropsondes, radiosondes and AROs, but are not available from satellite.

Model output can be used to calculate maps of IVT, as shown here.

AWIPS Volume Browser can now calculate the IVT by modifying the configuration files per the dan.txt file

Courtesy of B. Motta, M Kelsch, CIMMS

Thank You